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REPORT NO. 96-18

WIDE AREA MUNITION (WAM) PALLET MIL-STD-1660 AND RAIL IMPACT TESTS

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Prepared for:
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U.S. Army Armament Research, Development
and Engineering Center
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U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL
Savanna, Illinois

VALIDATION ENGINEERING DIVISION
SAVANNA, ILLINOIS 61074-9639

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The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SIOAC-DEV), was tasked by the U.S. Army Armament Research, Development and Engineering Center (ARDEC) to conduct MIL-STD-1660 and rail impact tests on the Wide Area Munition (WAM) pallet. This report contains the procedures, results, and recommendations from MIL-STD-1660, Design Criteria for Ammunition Unit Loads, and rail impact tests conducted. The final WAM pallet design successfully passed MIL-STD-1660 and rail impact tests.

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SAVANNA, IL 61074-9639

REPORT NO. 96-18

WIDE AREA MUNITION (WAM) PALLET MIL-STD-1660 AND RAIL IMPACT TESTS

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PART 1

INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SIOAC-DEV), was tasked by the U.S. Army Armament Research, Development and Engineering Center (ARDEC) to conduct MIL-STD-1660 and rail impact tests on the Wide Area Munition (WAM) pallet.

B. AUTHORITY. This test was conducted IAW mission responsibilities delegated by the U.S. Army Industrial Operations Command (IOC), Rock Island, IL.

C. OBJECTIVE. The objective of this series of tests was to ascertain whether or not the WAM pallet and container would be damaged during transportation.

D. CONCLUSION. Three pallet loads were tested before the design successfully passed. The first pallet failed the repetitive shock test. During the vibration cycle, the inner containers protruded roughly 1-inch past the edge of the top adapter, while the containers around the edge remained in synchronization with the motion of the pallet. Containers remained connected at all times at their stacking lugs, with no separation occurring. Internal banding was added to unitize the unstable layers of containers with those containers unaffected during testing. This allowed all of the containers to move in synchronization with the pallet during vibration cycles, although the tight bundling caused some slack in the fit of the top adapter.

The second design was identical to the first with the exception of the added bundling straps. A gap of approximately 1/2-inch remained between the top adapter and the container bell housing after the banding was tightened. Initial designs on the pallet adapters proved to be insufficiently stiff. The unusual length of the pallet required the adapters to have long

crossmembers which lose flexural rigidity as their length increases. This contributed to bowing in the top adapter after the banding was tightened. The design passed the vibration test; however, it failed the drop test. Deflection of the ends of the skids measured as much as 1-1/2 inches and as little as 1 inch where they were previously flush with the ground. Some unnesting of containers was observed as one of them became detached from the containers above at its stacking lug and protruded almost 2 inches from the pallet. Some mild racking of the containers was also observed, where each column was no longer observed to be completely vertical.

The third WAM pallet design included the following corrective actions. First, the angle of the lifting ring base plates was changed from 45 degrees to roughly 22 degrees thereby directing much of the banding resultant force vertically downward. This kept the top adapter from bowing up in the middle. Secondly, a thicker gage steel (10 gage) was used for the pallet adapters, which significantly stiffened the entire structure. Finally, the crossmembers of the top and bottom adapters had their channel sections deepened thereby increasing the stiffness and critical buckling load of the adapters. These corrective actions allowed the pallet to pass the drop test, the incline-impact test, and the sling test as well as the stacking and repetitive shock tests without any significant difficulties.

The rail impact test first had the WAM pallet placed so that the containers were oriented perpendicularly to the length of the car. Hence, the structural crossmembers were oriented along the length of the car. In this configuration, the pallet adapter was best able to resist the impact forces from the car endwall. No pallet damage occurred. With the pallet oriented 90 degrees from this configuration, the top adapter on one of the two pallets was slightly bent as the crossmembers do not provide support in this direction. The damage was minimal and did not prevent the pallet from passing the test. No container damage was found in either case.

The unusual length of the WAM pallet and the weight of the container loads made it necessary to strengthen the structure. Lack of restraint on the containers during the repetitive shock test led to the use of internal bundling straps. Changing to a thicker gage steel (12 gage to 10 gage) for the adapters was an initial step taken to strengthen the pallet. The length of the pallet adapter crossmembers made the top adapter vulnerable to bowing as the banding was tightened. The flexural rigidity of the members decreases as their length increases. The design solution was to change the cross-sectional profile of these members to provide more bending rigidity. An increase in the moment of inertia of the crossmembers about their neutral axis results in a structure that is stiffer in bending. Deepening the channel section from 0.935 inches to 1.875 inches along with an increase in gage thickness of the steel was the solution. Using a box beam section would have provided the greatest strength increase; however, it was not suitable for chemical agent resistance coating (CARC) painting. The following compares the <u>section moduli</u> Z (Z=I[moment of inertia]/C[distance to extreme fiber]) of various crossmember sections considered to that of the original section:

original =shallow U beam (12 G)
Deep Channel U(12 G) =3.78 x Z of original
Box Channel (12 G) =5.14 x Z of original
Shallow Channel U (10 G) = 1.22 x Z of original
Deep Channel U (10 G) = 4.78 x Z of original
Box Channel U (10 G) = 6.1 x Z of original

Choosing the deep channel 10 G section over the shallow channel 12 G section therefore resulted in a roughly five fold increase in the strength of the structure. This is found from S=M/Z where S is the maximum allowable stress (strength) for a given moment load M, and the chosen section modulus Z.

This change did in fact strengthen the adapters to the point where no bowing was observed after banding. The adapters stayed down tight on the tops of the containers. These changes resulted in an average adapter weight of 116 pounds each. The pallet (deck and skids) remained 12 gage steel and weighed approximately 127 pounds. The empty containers were 20 pounds each. The total gross weight of the pallet with empty containers, adapters, and banding is approximately 975 pounds. With the actual 45-pound munitions, the gross weight of the entire palletized load would be roughly 2,325 pounds. The pallet was tested at 2,700 pounds to account for possible later additions of packing and humidity sensors.

The final design consideration for the pallet involved ensuring adequate buckling strength in the adapter crossmembers. Large dynamic loads experienced during the rail impact test could damage the adapters and possibly the containers if buckling of the structural crossmembers was to occur. Data from the load cells were used in determining to what dynamic forces the pallet structure was actually subjected (see Part 8). Due to the irregular, damaged endwalls of the boxcar, load cell readings were not uniform at all points on the pallet. This provided data for a worst-case scenario whereby the pallet structure contacts the wall unevenly, causing large stress concentrations on certain parts of the structure with little or none on other areas. The maximum load at one of the crossmembers reached a peak of approximately 18,000 pounds; hence, the structural members must withstand buckling loads well above this.

To determine the buckling strength of the current design, the critical buckling load Pcr was found in the following manner. The length of the crossmembers on the final design was approximately 56.5 inches. The effective length of these sections in columnar loading is somewhat less due to the boundary conditions at the ends. Assuming that the crossmembers are completely constrained on either end due to the welds, the effective length Le is equal to one half the actual length L. Considering that AISI 1010 steel is the material used, the mechanical properties include a Young's modulus of 29,000,000 psi and a yield stress of 36,000 psi. To

determine which formula to use to calculate the critical buckling load for this crossmember, it is first necessary to find the critical slenderness ratio, denoted Cc, which for these given material properties is 126. Since both the effective slenderness ratio Le/r and the slenderness ratio L/r are less than 126 (r is the radius of gyration of the member), the member cannot be considered an Euler (long) column but instead is treated as a short to intermediate column where failure depends on both the yield strength and the modulus of elasticity. For this case then, a safe approximation of the critical buckling load Pcr is found using the following American Institute of Steel Construction parabolic formula for critical buckling stress:

$$\sigma_{cr}=\sigma_y(1-[(L\mathit{eff}/r)^2/2Cc^2)])$$

Then, multiplying this critical buckling stress by the cross-sectional area of the section gives the critical buckling load, which, for this case, was 29,738 pounds. Dividing by the actual highest load resulting from the rail impact, which was found to be approximately 18,000 pounds, gives a factor of safety of around 1.65. Therefore, the pallet is protected from even the worst-case scenario of impact loads. The crossmembers did not buckle during the actual rail impact test, as designed.

E. <u>RECOMMENDATIONS</u>: The current WAM pallet design is structurally sound and provides unitization integrity for the contents. One recommended change to the current design for future production of this pallet would be to round down the bottom edge of the lifting ring plate. The current design has the banding passing over a sharp edge where it could shear off if hit with enough force (see Part 6, page 9).

PART 2

15 AND 21 FEBRUARY; 1, 4, AND 26 MARCH; AND 2 APRIL 1996

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PART 3

TEST PROCEDURES

The test procedure outlined in this section was extracted from MIL-STD-1660, Design Criteria for Ammunition Unit Loads, 8 April 1977. This standard identifies nine steps that a unitized load must undergo if it is considered to be acceptable. The five tests that were conducted on the test pallet are synopsized below:

A. STACKING TEST. The unit load was loaded to simulate a stack of identical unit loads stacked 16 feet high for a period of one hour. This stacking load was simulated by subjecting the unit load to a compression weight equal to an equivalent 16-foot stacking height. The compression load is calculated in the following manner. The unit load weight is divided by the unit load height in inches and multiplied by 192. The resulting number is the equivalent compressive force of a 16-foot-high load.

B. REPETITIVE SHOCK TEST. The repetitive shock test was conducted IAW Method 5019, Federal Standard 101. The test procedure is as follows: The test specimen was placed on, but not fastened to the platform. With the specimen in one position, the platform was vibrated at 1/2-inch amplitude (1-inch double amplitude) starting at a frequency of approximately 3-cycles per second. The frequency was gradually increased until the package left the platform. The resonant frequency is achieved when a 1/16-inch-thick feeler gage can be momentarily slid freely between every point on the specimen in contact with the platform at some instance during the cycle, or the platform acceleration achieves 1+/-0.1 G. Midway into the testing period, the specimen was rotated 90 degrees and the test continued for the duration. Unless failure occurs, the total time of vibration is two hours when the specimen is tested in one position. When the specimen is tested in more than one position, the total time is three hours.

C. EDGEWISE ROTATIONAL DROP TEST. This test was conducted using the procedures of Method 5008, Federal Standard 101. The procedure for the Edgewise Rotational Drop Test is as follows: The specimen was placed on its skids with one end of the pallet supported on a beam 4-1/2 inches high. The height of the beam was increased, when necessary, to ensure that there was no support for the skids between the ends of the pallet when the drop took place, but was not high enough to cause the pallet to slide on the supports when the dropped end was raised. The unsupported end of the pallet was then raised and allowed to fall freely to the concrete, pavement, or similar underlying surface from a prescribed height. Unless otherwise specified , the height of drop for level A protection shall conform to the following tabulation.

GROSS WEIGHT (Pounds)	DIMENSIONS ON ANY EDGE (Inches)	HEIGHT OF DROP LEVEL A PROTECTION (Inches)
150 - 25-	60 - 66	36
250 - 400	66 - 72	32
400 - 600	72 - 80	28
600 - 1000	80 - 95	24
1000 - 1500	95 - 114	20
1500 - 2000	114 - 144	17
2000 - 3000	Above 145 - No limit	15
Above - 3000		12

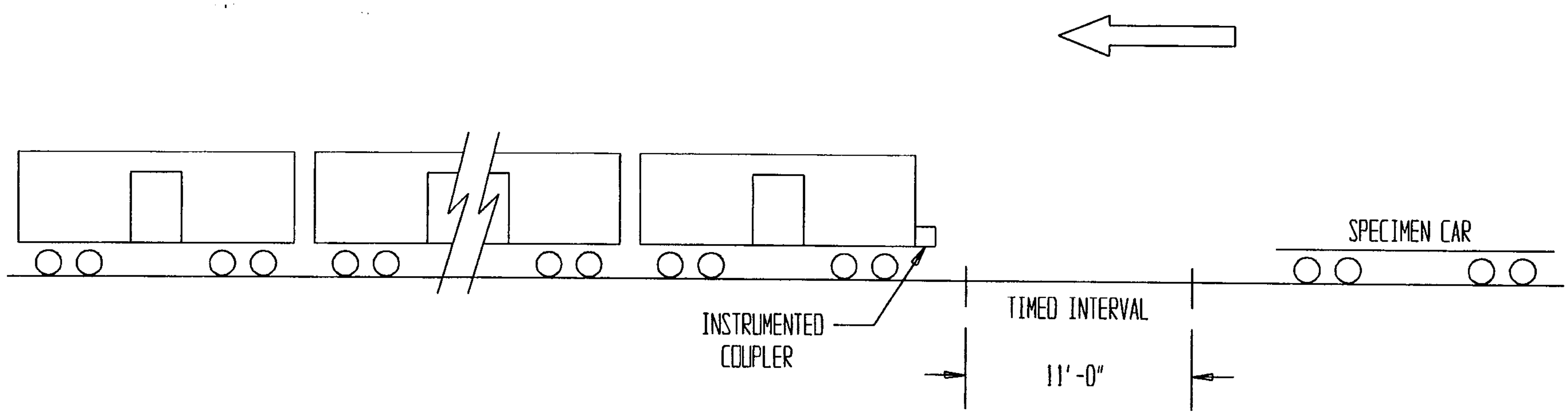
D. INCLINE-IMPACT TEST. This test was conducted using the procedure of Method 5023, Incline-Impact Test of Federal Standard 101. The procedure for the incline-impact test is as follows: The specimen was placed on the carriage with the surface or edge to be impacted projecting at least 2 inches beyond the front edge of the carriage. The carriage was brought to a predetermined position on the incline and released. If it is desired to concentrate the impact on any particular position on the container, a 4- by 4-inch timber may be attached to the bumper in

the desired position before the test. No part of the timber was struck by the carriage. The position of the container on the carriage and the sequence in which surfaces and edges were subjected to impacts was at the option of the testing activity and depended upon the objective of the tests. When the test is to determine satisfactory requirements for a container or pack, and, unless otherwise specified, the specimen was subjected to one impact on each surface that has each dimension less than 9.5 feet. Unless otherwise specified, the velocity at the time of impact was roughly 7 feet-per-second.

E. RAIL IMPACT TESTS: Following the general guidelines of the Transportability Testing Procedures, TP-94-01, July 1994, the WAM pallets were tested in two perpendicular orientations with inert loads, dunnage, and blocking and bracing as shown in part 7. Along with the loaded railcar (hammer), five empty railcars connected together (anvil) and the locomotive were needed to conduct the test. The anvil cars were positioned on a level section of track with air and hand brakes set and the draft gear compressed. The locomotive unit pulled the test car several hundred yards away from the anvil cars and then pushed the test car towards the anvil at a predetermined speed. The locomotive was disconnected from the test car at approximately 50 yards from the anvil cars, after which the test car rolled freely until it impacted the target. Impacts were carried out at speeds of 4,6, and 8 mph in one direction, followed by an impact of 8 mph with the test car turned in the opposite direction. The 8 mph speed is considered a minimum for the test to be valid. Opto-electronic sensors were used to measure the time for the car to traverse an 11-foot distance immediately prior to contacting the anvil cars (see Figure 1). At the discretion of the test engineer, additional impacts at higher or lower speeds may be conducted on the specimen car for engineering test data after the conclusion of the four required rail impacts. Instrumentation in the form of load cells was included on one of the WAM pallets to gather data which proves useful in establishing pallet design criteria. After each impact, load force data were downloaded from the data acquisition system aboard the test railcar to a computer back in the test facility via a brief connection with wires running from the test site to the lab. Following each impact, the inside of the test railcar was inspected for damage to the test

pallets and for excessive shifting of contents or breakage of supports. Testing may halt if the test engineer determines that the pallet has failed or if the loosening of the car contents represents a safety hazard.

ASSOCIATION OF AMERICAN RAILROADS (AAR)
STANDARD TEST PLAN



5 BUFFER CARS (ANVIL) WITH DRAFT GEAR COMPRESSED AND AIR BRAKES IN A SET POSITION

ANVIL CARS TOTAL WT 250,000 LBS (APPROX)

SPECIMEN CAR
IS RELEASED BY
SWITCH ENGINE TO

ATTAIN: IMPACT NO. 1 @ 4 MPH
IMPACT NO. 2 @ 6 MPH
IMPACT NO. 3 @ 8.1 MPH

THEN THE CAR IS REVERSED AND RELEASED BY SWITCH ENGINE TO

ATTAIN: IMPACT NO 4. @ 8.1 MPH

FIGURE 1

PART 4

TEST EQUIPMENT

A. TEST PALLET.

1. Height:	41.38 inches
2. Width:	44.00 inches
3. Length:	56.50 inches
4. Weight:	2,700 pounds (975 pounds without inert filler)

B. COMPRESSION TESTER.

1. Manufacturer:	Ormond Manufacturing
2. Platform:	60 inches by 60 inches
3. Compression Limit:	50,000 pounds
4. Tension Limit:	50,000 pounds

C. TRANSPORTATION SIMULATOR.

1. Manufacturer:	Gaynes Laboratory
2. Capacity:	6,000-pound pallet
3. Displacement:	1/2-inch amplitude
4. Speed:	50 to 400 rpm
5. Platform:	5- by 8-foot

D. INCLINED PLANE.

1. Manufacturer:	Conbur Incline
2. Type:	Impact tester
3. Grade:	10 percent incline
4. Length:	12 foot incline

E. RAILCAR.

1. Car Type:	Burlington Northern Boxcar No. 250479
2. Length:	50-foot (approximate)
3. Width:	10-foot (approximate)
4. Weight:	154,000 pounds
5. Draft Gear:	Friction

F. DATA ACQUISITION EQUIPMENT.

1. Manufacturer:	Pacific Scientific
2. Number of Channels Used:	8

The weight of the test pallet artificially increased by adding an extra 10 pounds of inert filler per container to compensate for the weight of future additions such as humidity sensors, packing, etc. The actual gross weight of this pallet with munitions (assuming 45-pound mines) is roughly 2,325 pounds.

PART 5

TEST RESULTS

Each 20-pound modified PA160 WAM container was filled with 55 pounds of inert load for a total weight per container of 75 pounds. The containers were then palletized for testing.

A. STACKING TEST. The WAM pallet was loaded to roughly 13,500 pounds of compression. The compression lasted 1 hour after which no damage was noted on either pallet.

B. REPETITIVE SHOCK TEST: The duration of the test was 90 minutes for each orientation of the pallet. In order to achieve resonance, the dial was set to 190 rpm when the long side of the pallet was facing outward from the front of the table, and 180 rpm when the short side was facing outward. Earlier designs on the first pallet were unable to keep the containers from swinging out past the edge of the top adapter during a vibration cycle. The top adapter did not hold the containers tightly in place. On the final design of the first pallet and on the second pallet, the test was passed successfully.

C. EDGEWISE ROTATIONAL DROP TEST. Each side of the pallet was placed on a beam displacing it 4-1/2 inches above the floor. The opposite end of the pallet was raised to a height of nearly 18 inches, then dropped. A height of 18 inches was employed instead of the specified 15 inches due to the dimensions of the pallet. Drops resulted in damage to the ends of the skids in the earlier design of the first pallet, bending them upward by as much as 1.5 inches. This made the pallets unstackable due to the unstable wobble induced by the bent skids. The drop caused one container to loosen from its stacking lug as well as a slight racking of the entire load. No significant damage occurred to the final design of the first pallet or to the second pallet.

D. INCLINE-IMPACT TEST. The inclined plane was set to allow the pallets to travel 8 feet prior to impacting a stationary wall. The pallet was rotated clockwise after each impact, until all four sides had been tested. No damage to either pallet was noted.

E. RAIL IMPACT TEST. After both WAM pallets had passed MIL-STD-1660 tests, they were subjected to a rail impact test. One WAM pallet was placed at each end of a row of pallets in a boxcar. Wood dunnage and 155mm propelling charge container pallets were used as inert fill for the rest of the load (see Part 7). Transducers were placed on the ends of one of the pallets. Eight transducers were used to record the dynamic load acting on each of the structural crossmembers of the pallet (see results in Part 8). Speeds recorded for the various impacts were 3.98 mph, 5.86 mph, 9.49 mph, and 8.90 mph in the reverse direction. When the pallets were aligned with the containers perpendicular to the length of the railcar, no damage to either pallet occurred. When aligned with the containers parallel to the length of the railcar, slight damage was found on one side of the top adapter of one of the pallets. There was no damage to the containers. In the first alignment, the structural integrity of the pallet was superior to the second alignment because the structural crossmembers were in position to absorb impact forces through the adapters. A gap of approximately 10 inches opened between the endwall of the railcar and the end of the WAM pallet on the final collision. The poor condition of these inert loads contributed to the gap, as some could not resist the compressive forces of the impacts and yeilded slightly.

PART 6

PHOTOGRAPHS

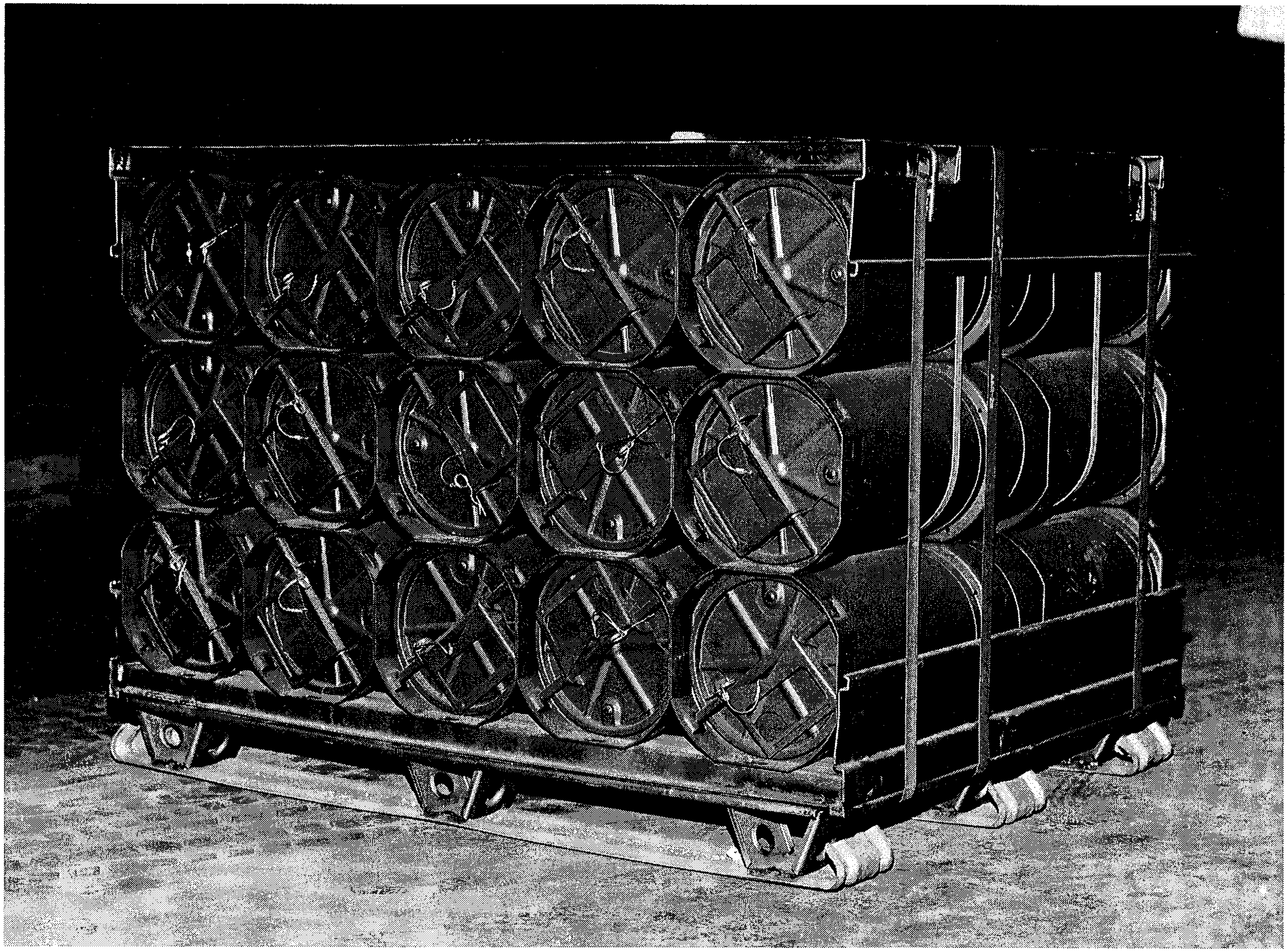


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PHOTO NO. A0317-SCN-96-105-2207. This photo shows the WAM pallet unitized load after completion of MIL-STD-1660 tests.

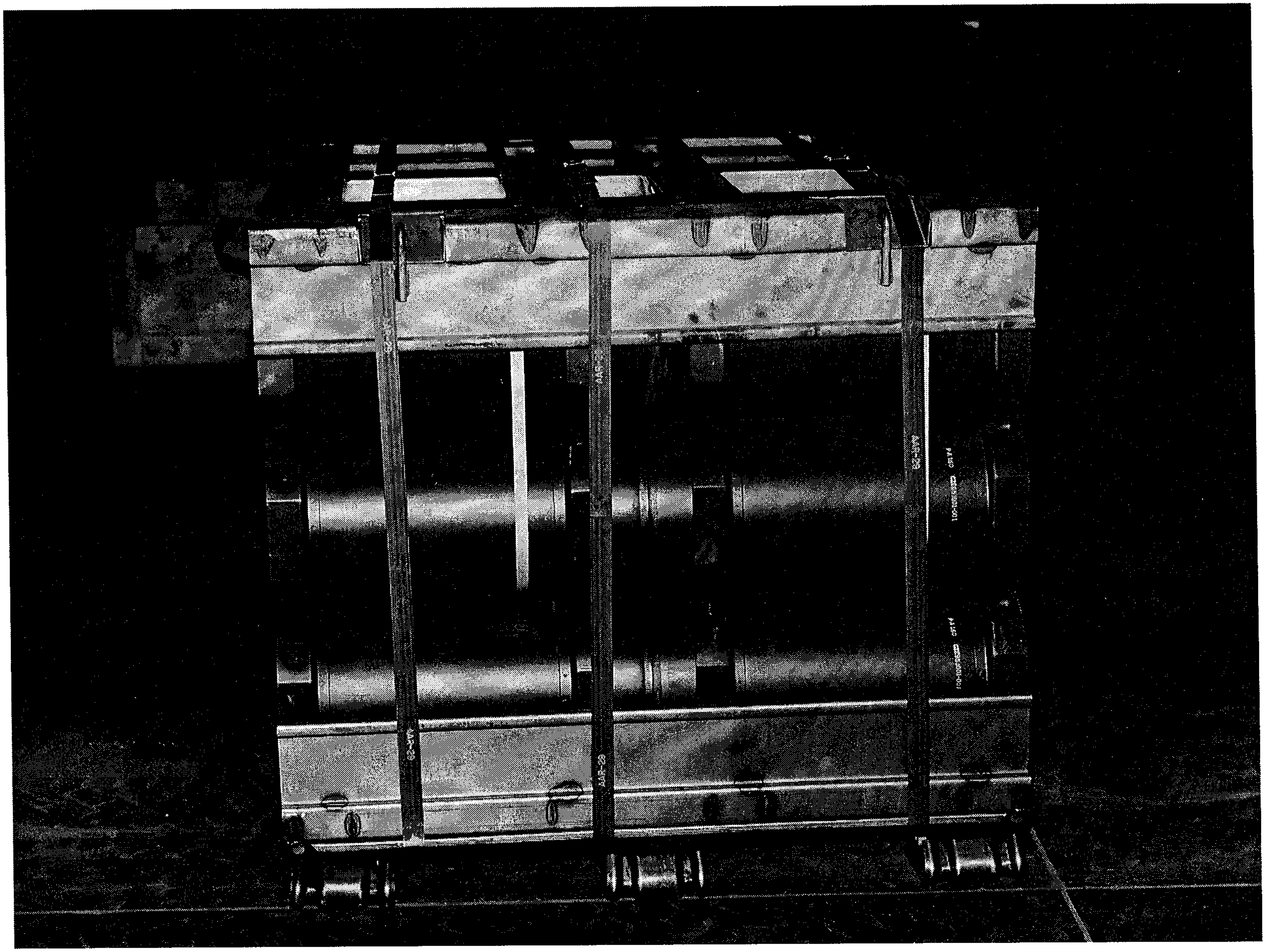

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PHOTO NO. A0317-SCN-96-105-2205. This photo shows a side view of the WAM pallet unitized load after completion of MIL-STD-1660 tests.		

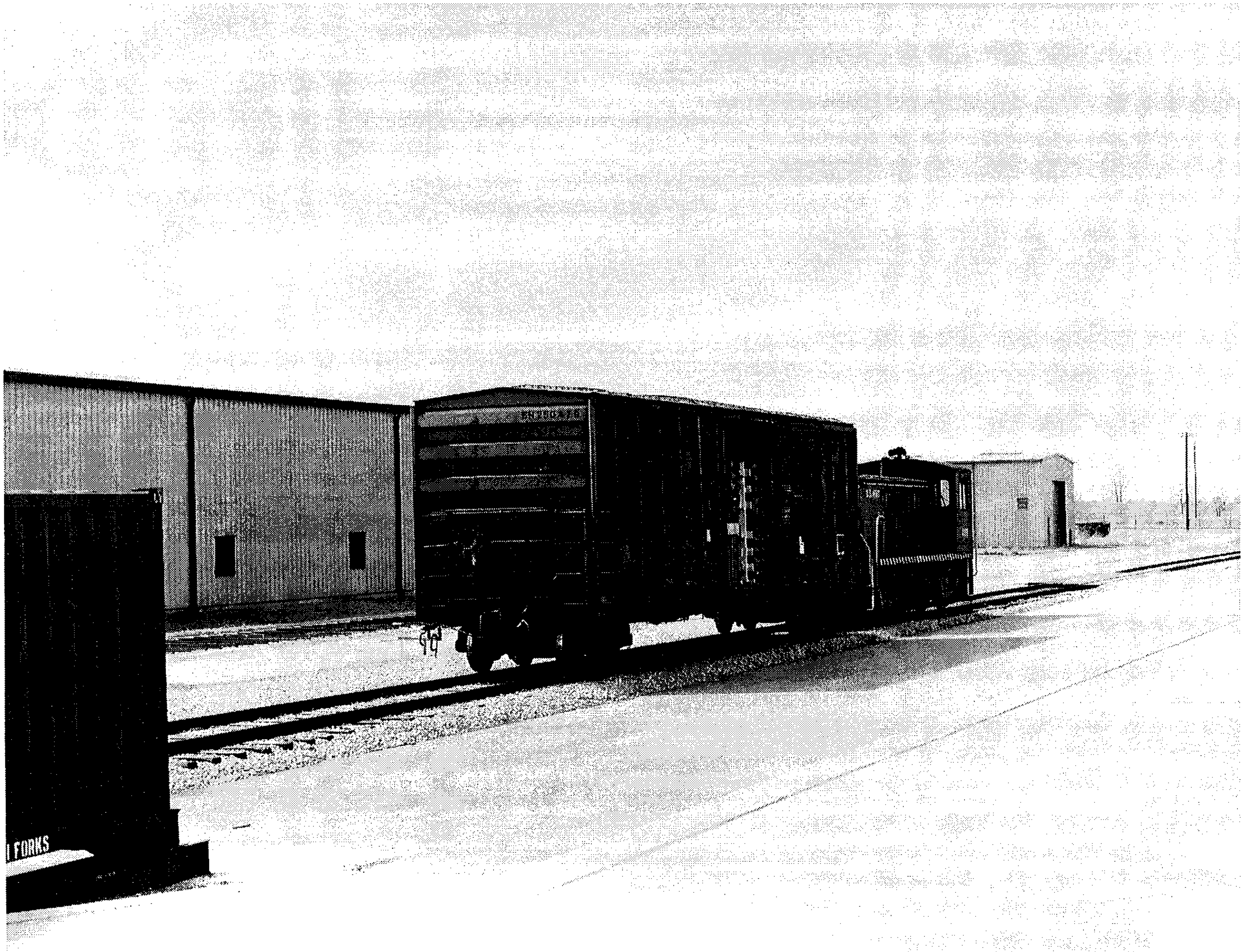

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PHOTO NO. A0317-SCN-96-106-2241. This photo shows the loaded boxcar during the rail impact test.

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PHOTO NO. A0317-SCN-96-105-2195. This photo shows an inside view of the railcar with the full test load. The two test pallets are located at either end of the row on the right, while the other inert loads are palletized 155mm propelling charge containers. Note the portable data acquisition system in the center aisle used to collect data from the load cells.

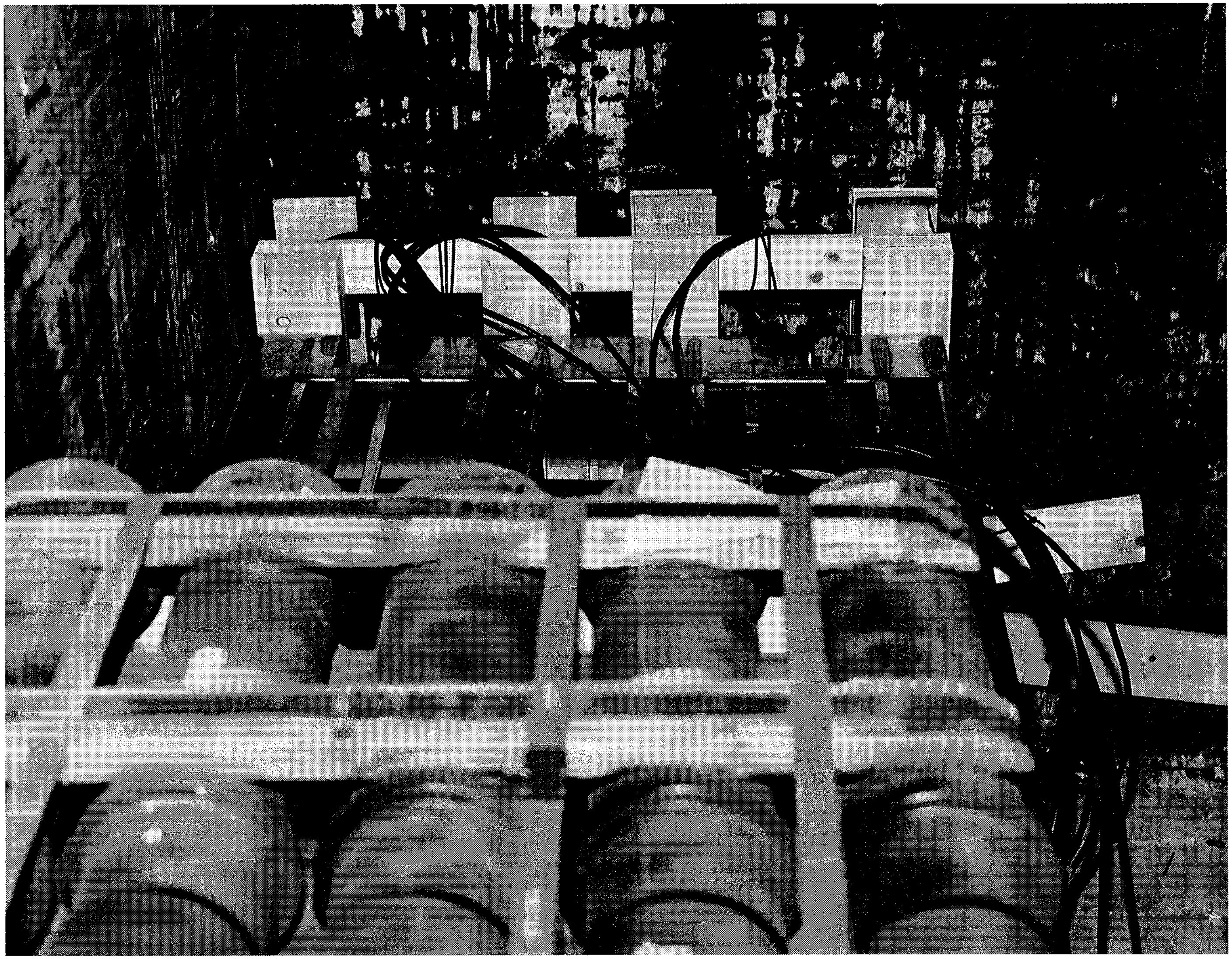

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PHOTO NO. A0317-SCN-96-105-2199. This photo shows the WAM pallet loaded against the end wall of the boxcar. Notice the wood dunnage between the test pallet and the wall, which contains the load cells.

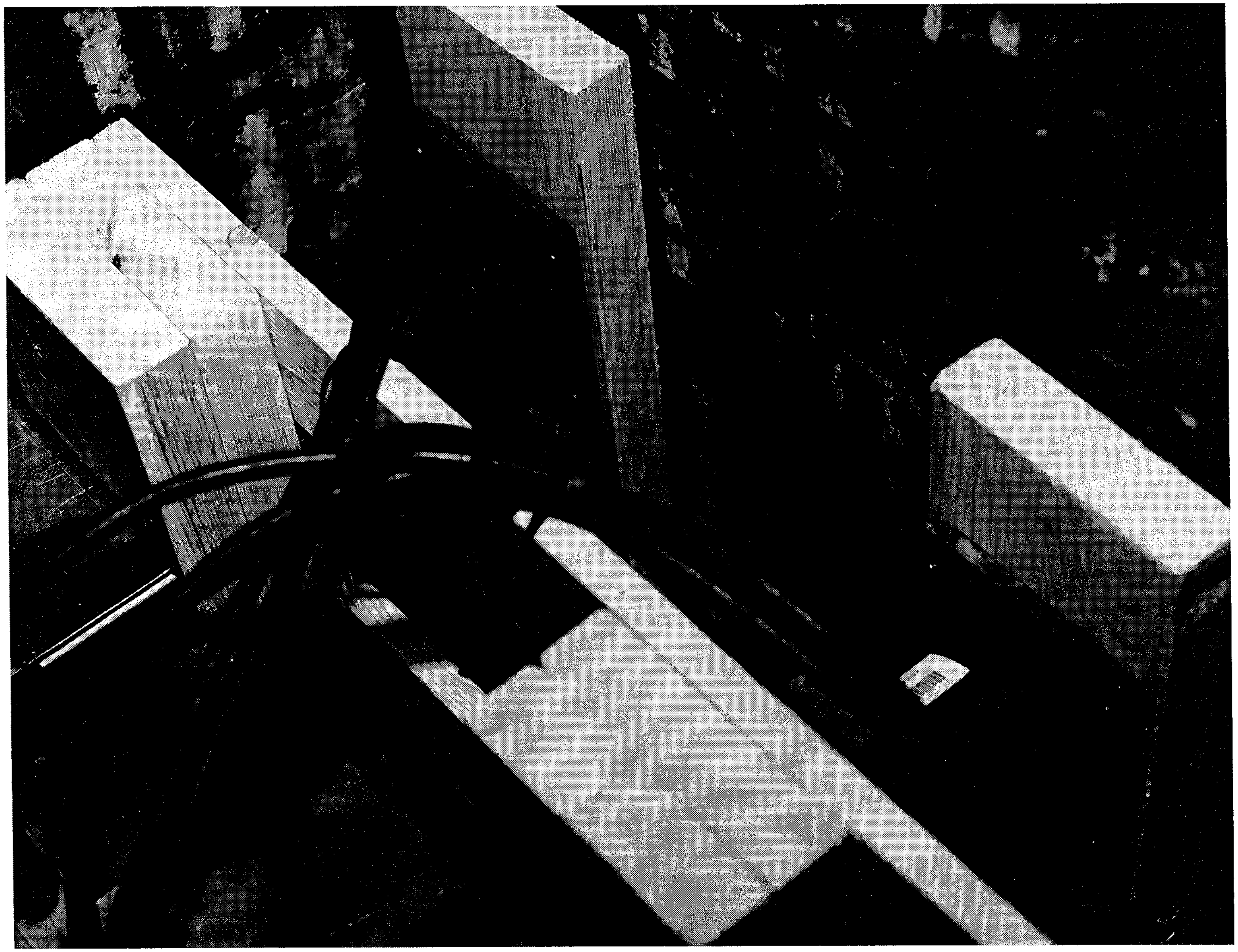

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PHOTO NO. A0317-SCN-96-105-2194. This photo shows a close-up view of the load cell placement between the end wall of the railcar and the pallet. They are positioned so that one load cell is located at the head of each of the pallet adapter crossmembers with the center of each cell aligned with the center of each crossmember.

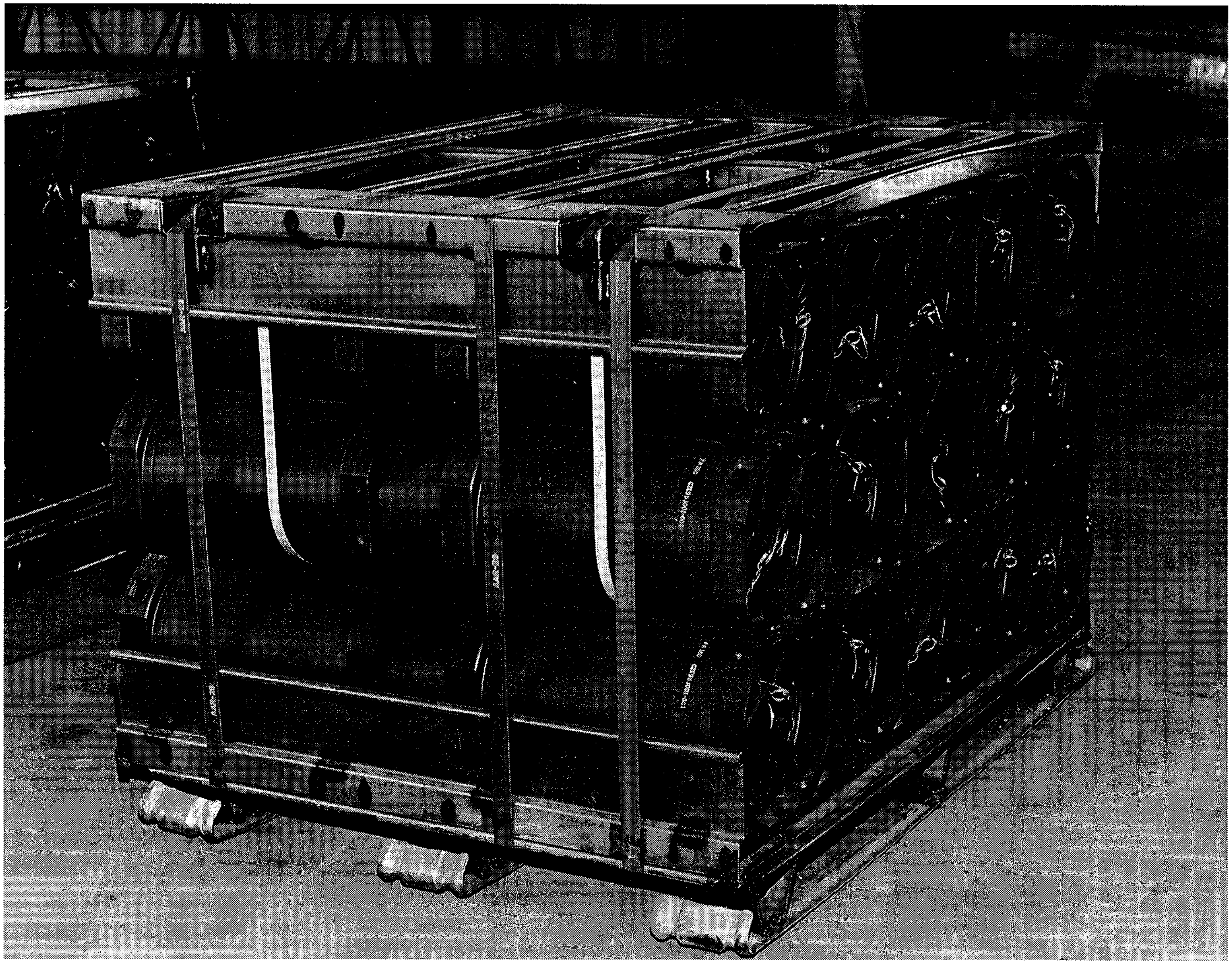

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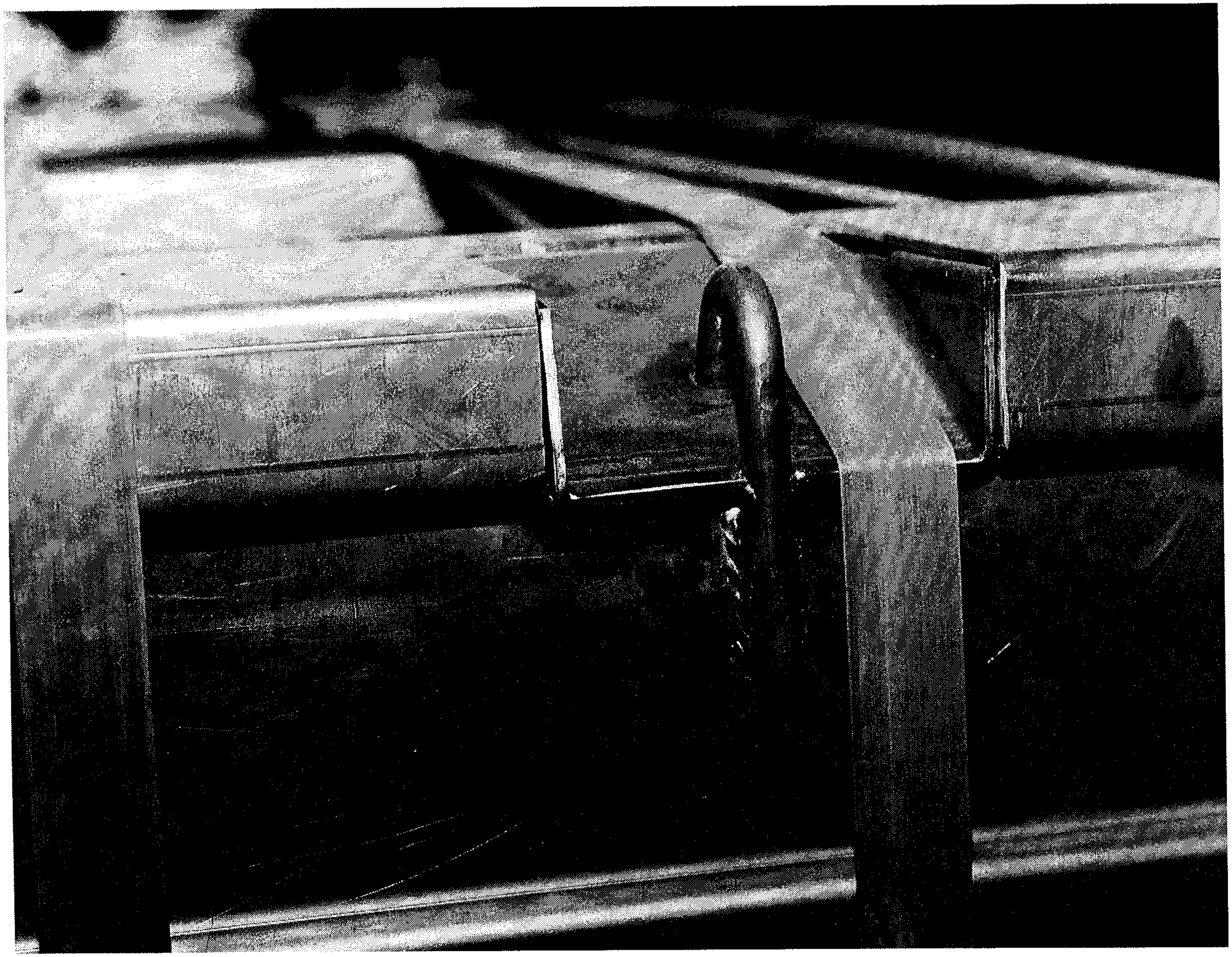
PHOTO NO. A0317-SCN-96-115-2411. This photo shows one of the two pallets after the rail impact test. The only damage to either pallet can be seen along one edge of the top adapter of one of the pallets, where one of the crossmembers is bent slightly inward.

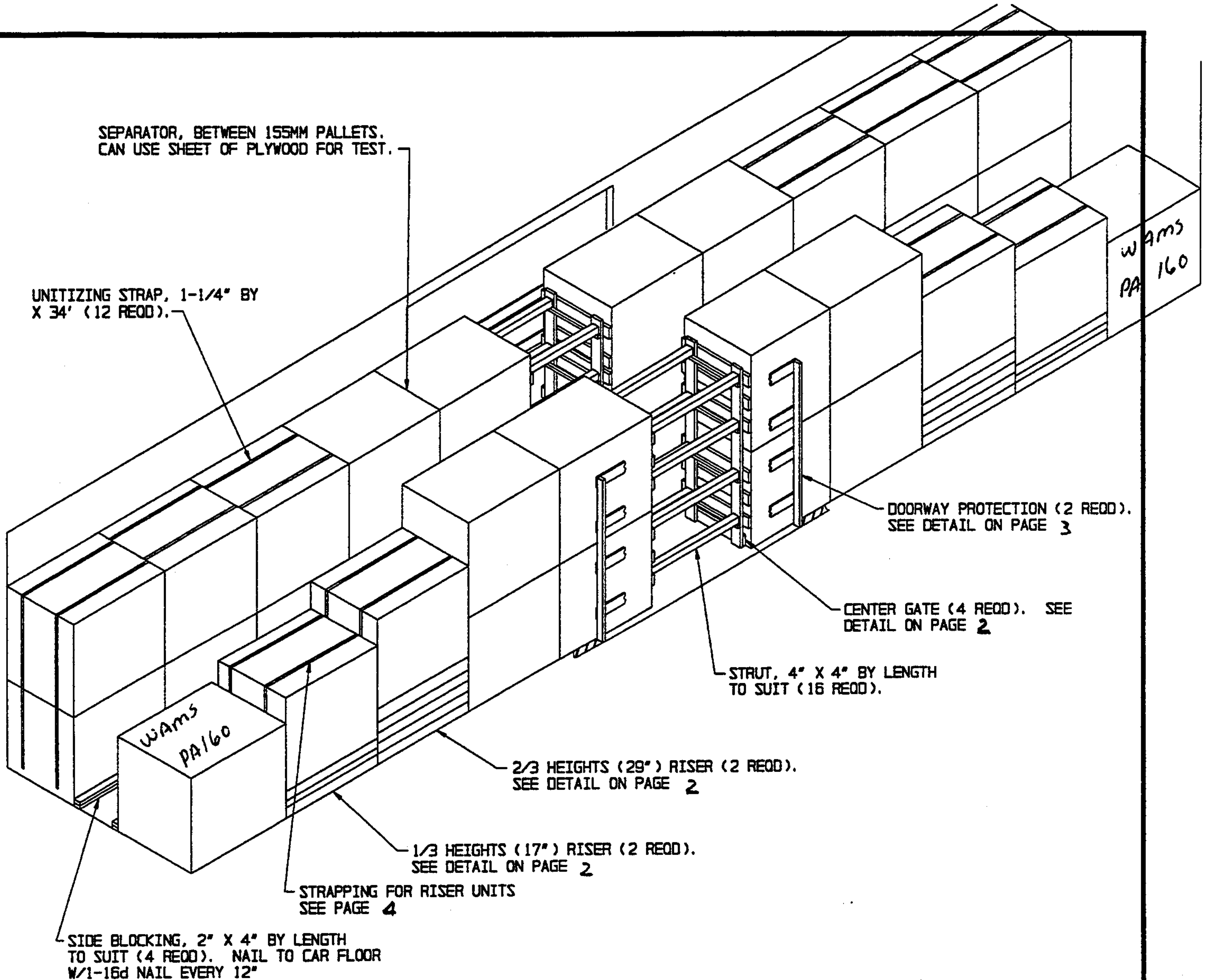


U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

PHOTO NO. A0317-SCN-96-115-2412. This photo shows the lifting ring base plate. The sharp edge over which the banding passes should be changed by extending the edge downward on future production runs of this pallet.

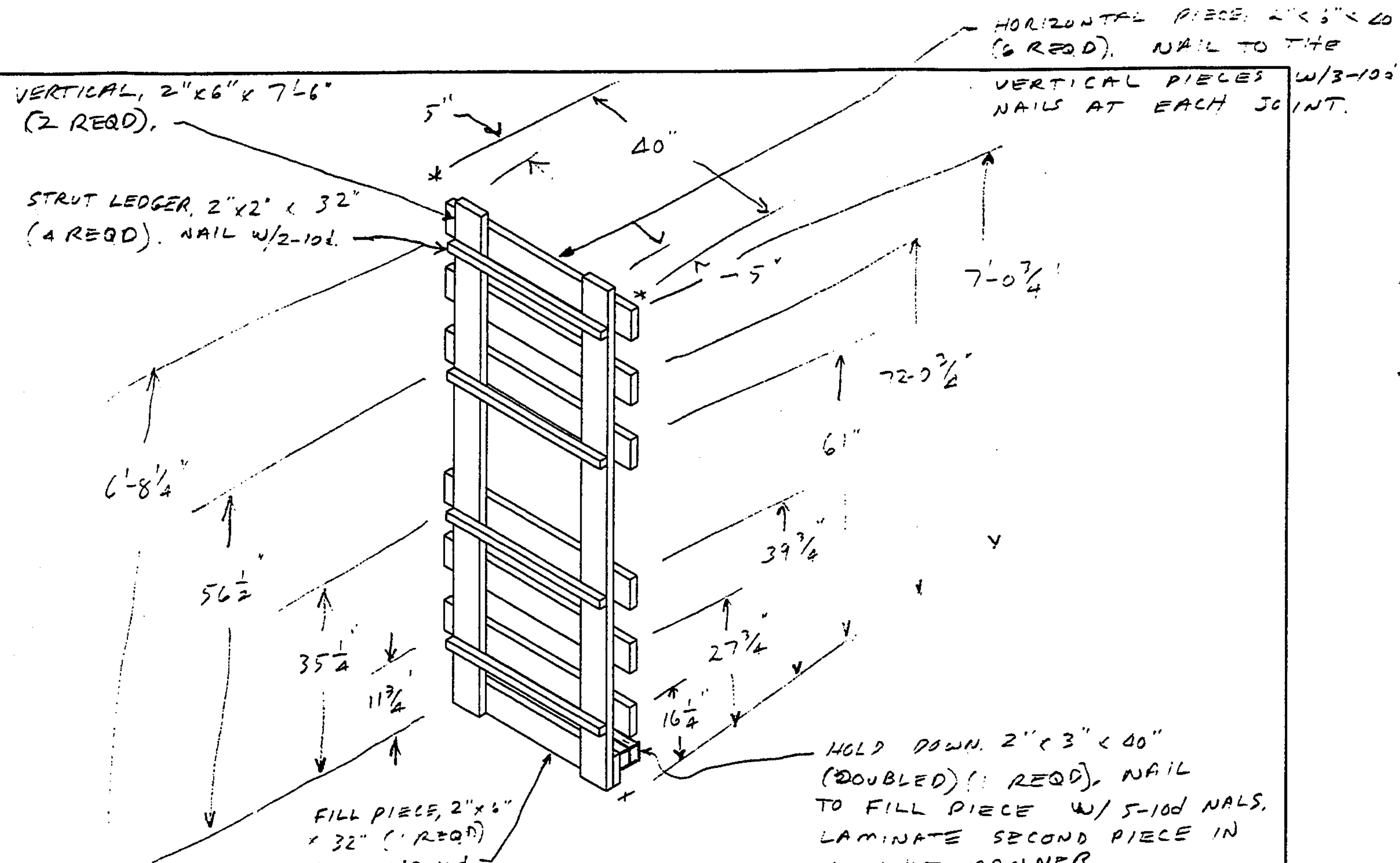
PART 7

DRAWINGS

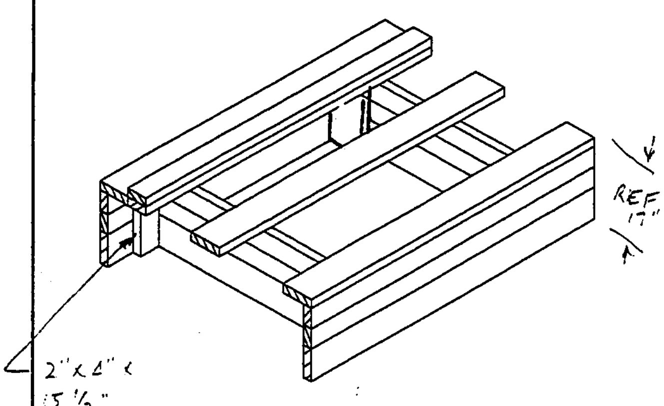


32 Pallets 155mm

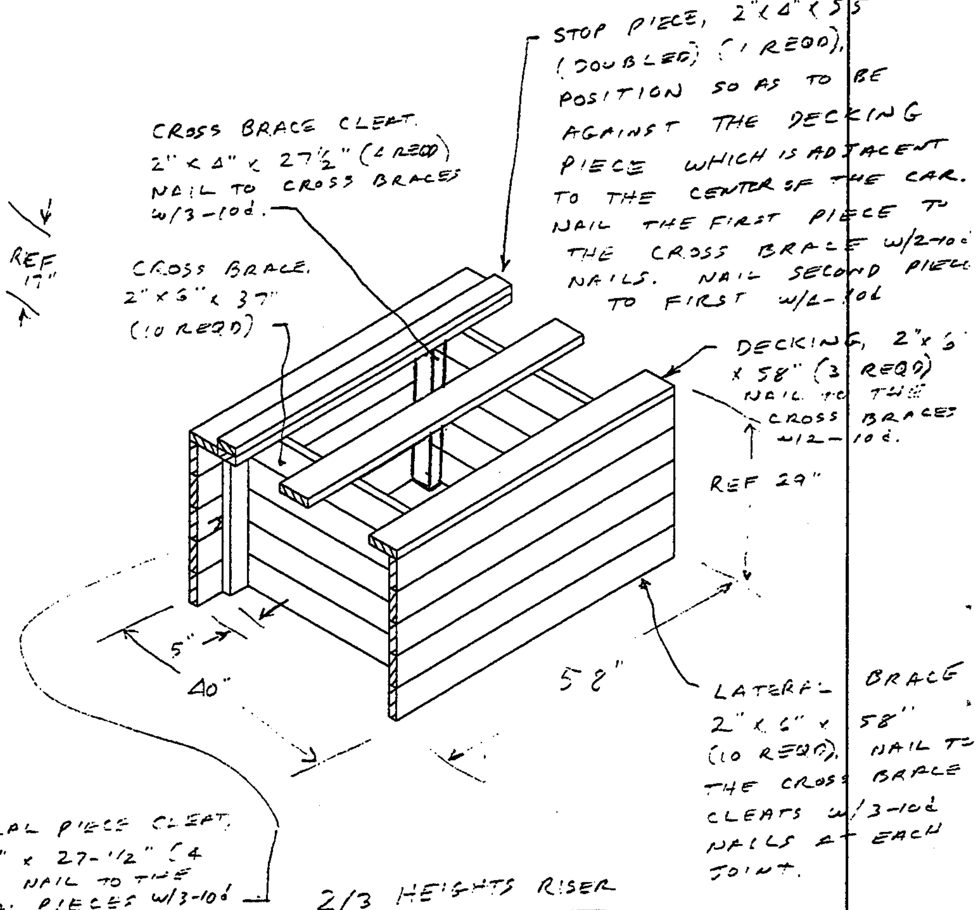
2 WAMS (PA 160) Pallet units



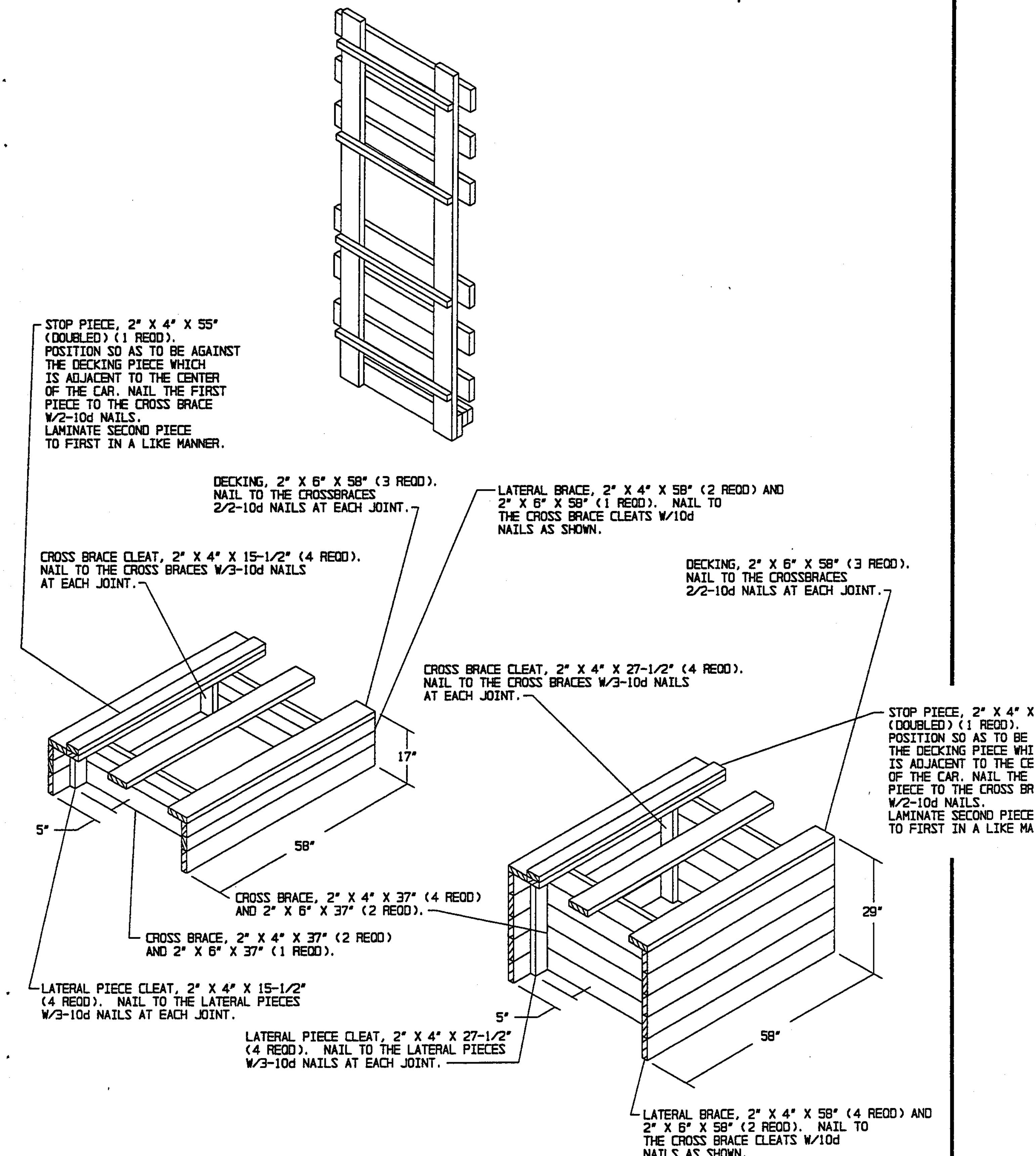
CENTER GATE

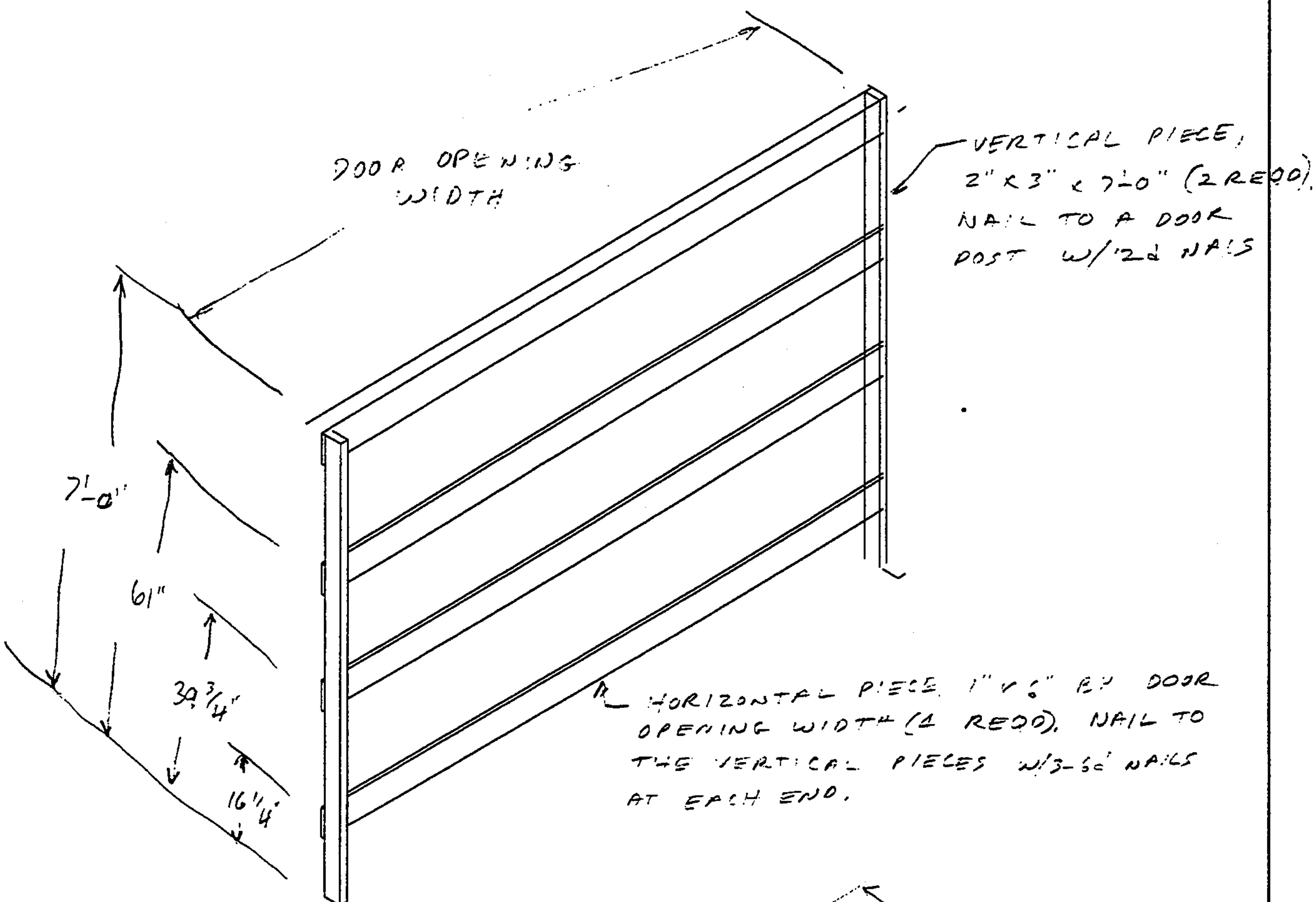


1/3 HEIGHT RISER

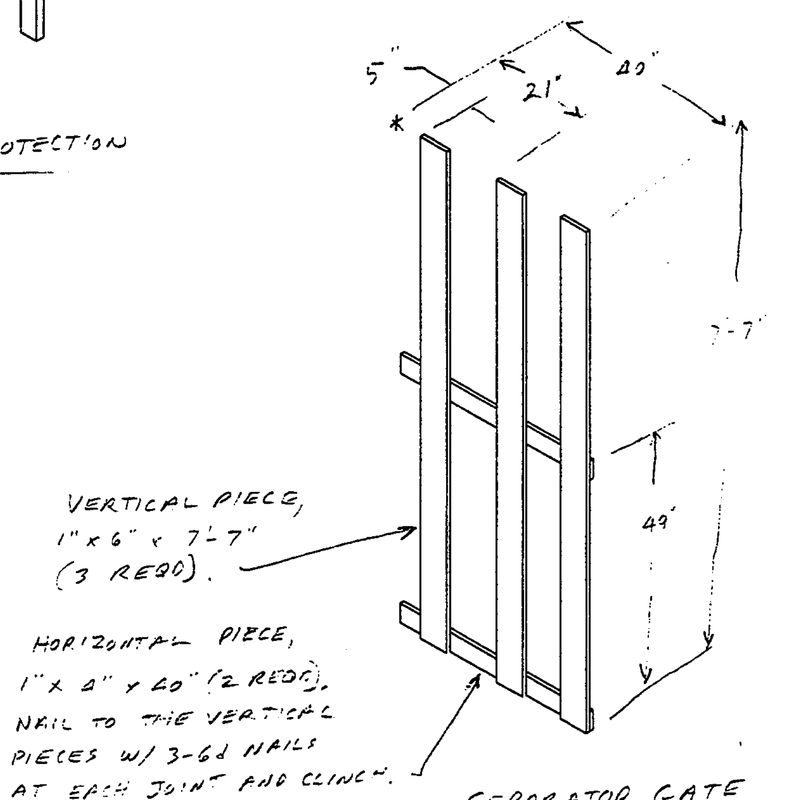


2/3 HEIGHTS RISER


STOP PIECE, 2" X 4" X 55" (DOUBLED) (1 REQD). POSITION SO AS TO BE AGAINST THE DECKING PIECE WHICH IS ADJACENT TO THE CENTER OF THE CAR. NAIL THE FIRST PIECE TO THE CROSS BRACE W/2-10d NAILS. LAMINATE SECOND PIECE TO FIRST IN A LIKE MANNER.
DECKING, 2" X 6" X 58" (3 REQD). NAIL TO THE CROSSBRACES 2/2-10d NAILS AT EACH JOINT.
LATERAL BRACE, 2" X 4" X 58" (2 REQD) AND 2" X 6" X 58" (1 REQD). NAIL TO THE CROSS BRACE CLEATS W/10d NAILS AS SHOWN.
CROSS BRACE CLEAT, 2" X 4" X 15-1/2" (4 REQD). NAIL TO THE CROSS BRACES W/3-10d NAILS AT EACH JOINT.
DECKING, 2" X 6" X 58" (3 REQD). NAIL TO THE CROSSBRACES 2/2-10d NAILS AT EACH JOINT.
CROSS BRACE CLEAT, 2" X 4" X 27-1/2" (4 REQD). NAIL TO THE CROSS BRACES W/3-10d NAILS AT EACH JOINT.
17"
STOP PIECE, 2" X 4" X (DOUBLED) (1 REQD). POSITION SO AS TO BE THE DECKING PIECE WHI IS ADJACENT TO THE CE OF THE CAR. NAIL THE PIECE TO THE CROSS BR W/2-10d NAILS. LAMINATE SECOND PIECE TO FIRST IN A LIKE MA
5"
58"
CROSS BRACE, 2" X 4" X 37" (4 REQD) AND 2" X 6" X 37" (2 REQD).
29"
CROSS BRACE, 2" X 4" X 37" (2 REQD) AND 2" X 6" X 37" (1 REQD).
LATERAL PIECE CLEAT, 2" X 4" X 15-1/2" (4 REQD). NAIL TO THE LATERAL PIECES W/3-10d NAILS AT EACH JOINT.
5"
58"
LATERAL PIECE CLEAT, 2" X 4" X 27-1/2" (4 REQD). NAIL TO THE LATERAL PIECES W/3-10d NAILS AT EACH JOINT.
LATERAL BRACE, 2" X 4" X 58" (4 REQD) AND 2" X 6" X 58" (2 REQD). NAIL TO THE CROSS BRACE CLEATS W/10d NAILS AS SHOWN.

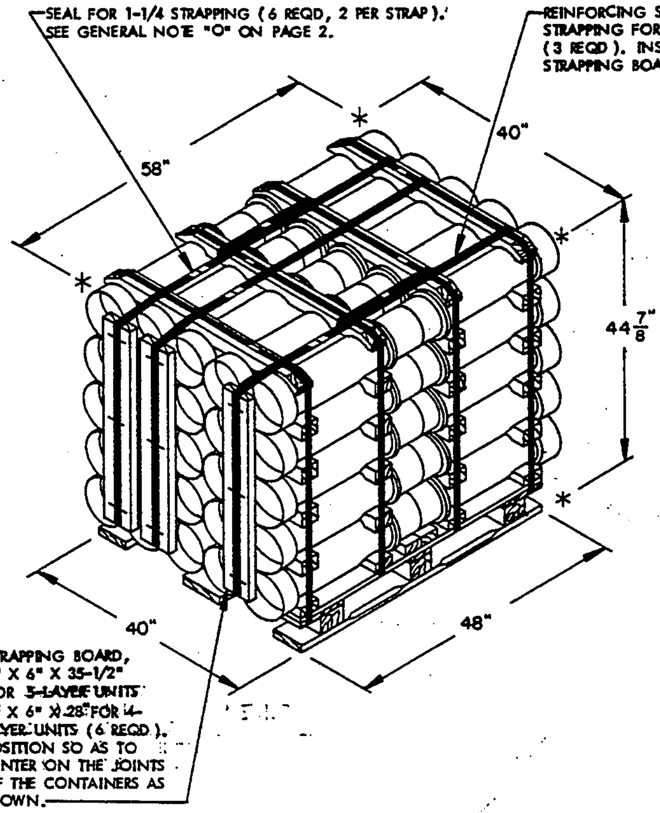


DOORWAY PROTECTION



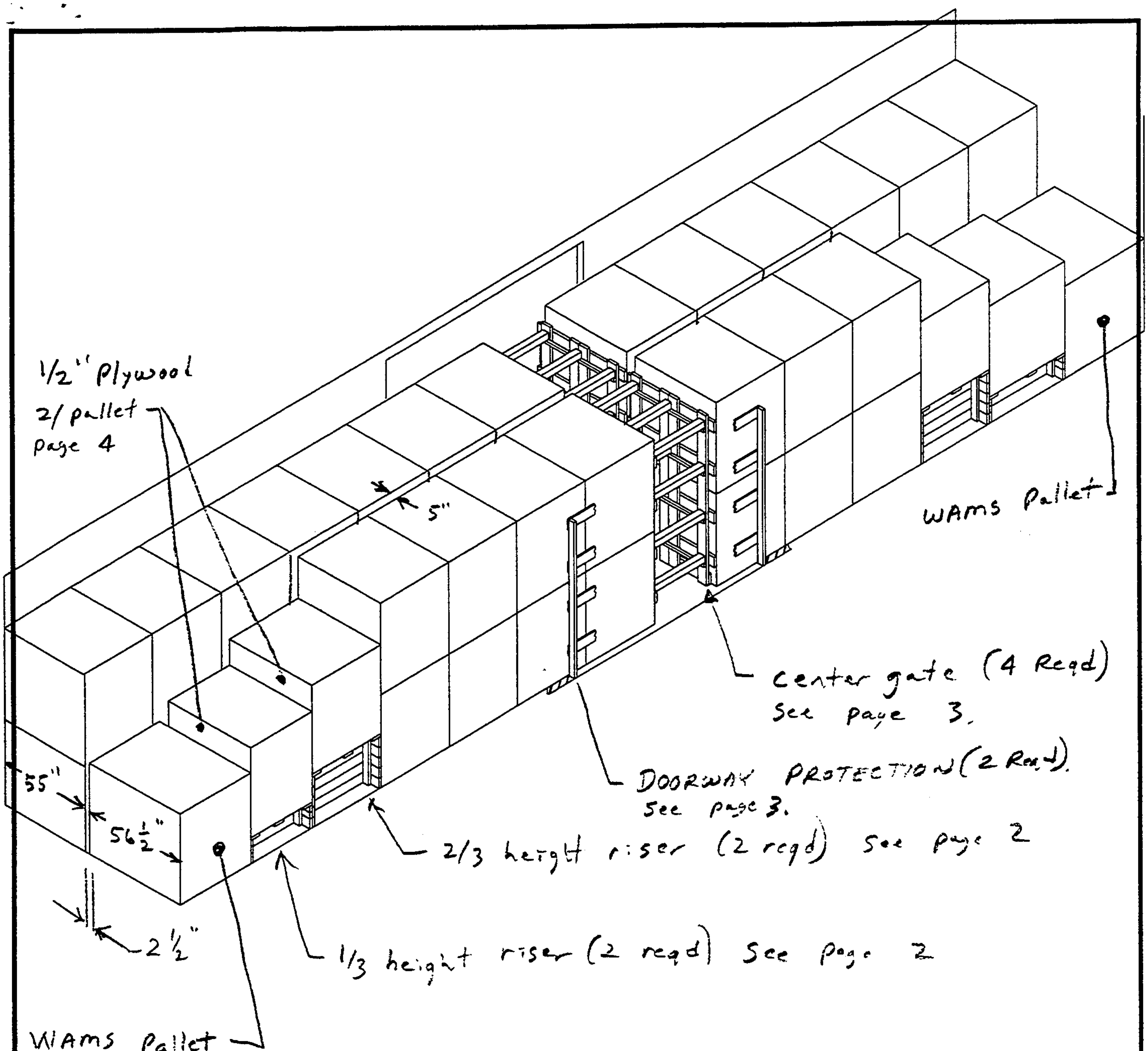
SEPARATOR GATE

RIGHT HAND AND LEFT HAND GATES ARE REQUIRED.

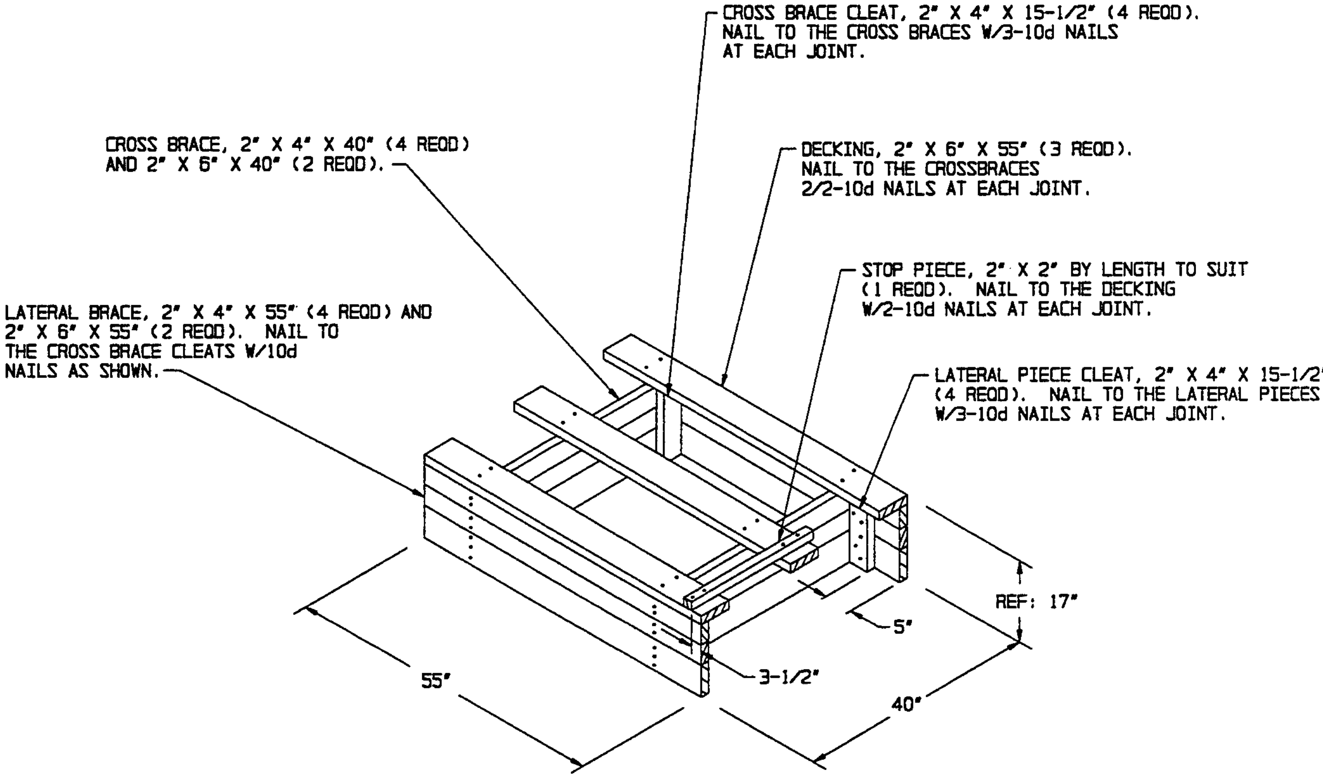


NOTE:

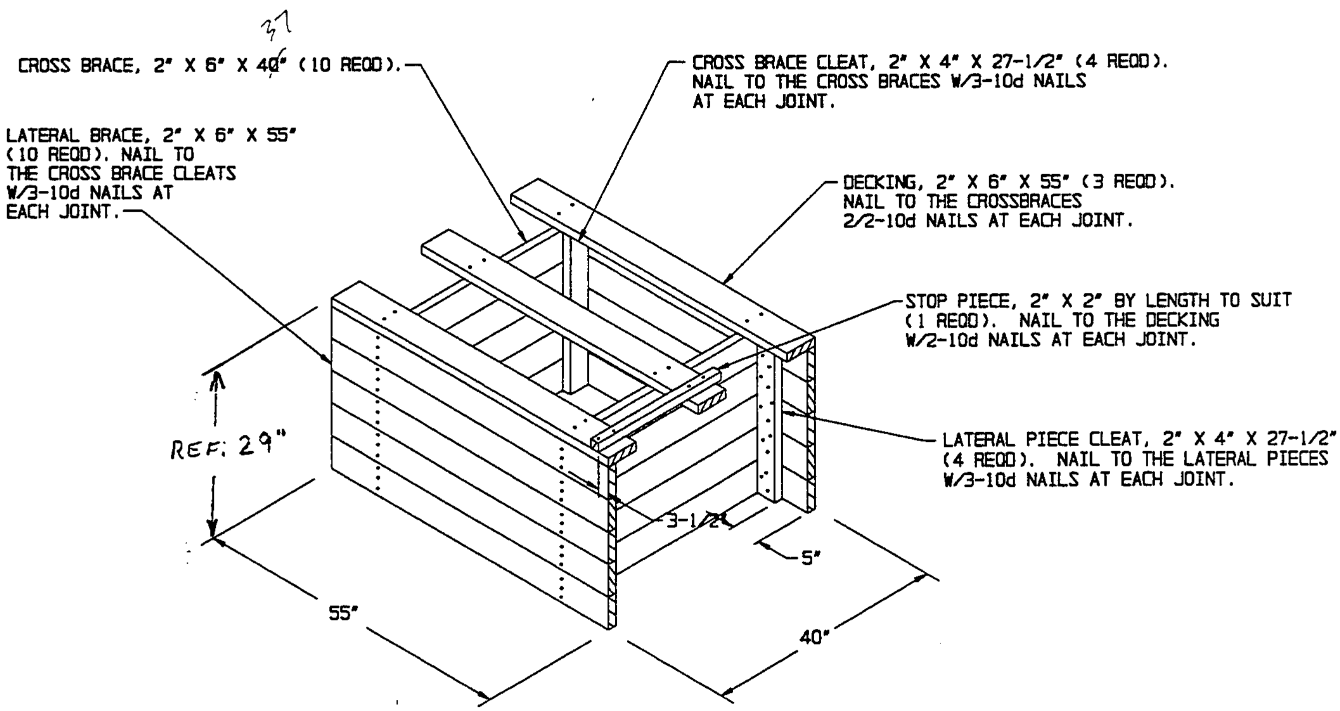
THE "METHOD A" DETAIL AT LEFT SHOWS THE MODIFICATION REQUIRED FOR PALLET UNITS WHICH ARE TO BE POSITIONED LENGTHWISE IN A CAR WHEN USING THE RISER METHOD OF PARTIAL-LAYER BRACING SHOWN ON PAGE 74. THE BASIC HEIGHT ROUTED DUNNAGE METHOD UNIT IS SHOWN.
THE PROCEDURES ARE APPLICABLE FOR ALL THE UNITS COVERED BY THIS DOCUMENT. FOR MODIFICATION OF UNITS TO BE POSITIONED CROSSWISE IN A CAR, REFER TO THE "METHOD B" DETAIL BELOW AND/OR THE "METHOD C" DETAIL ON PAGE 77.



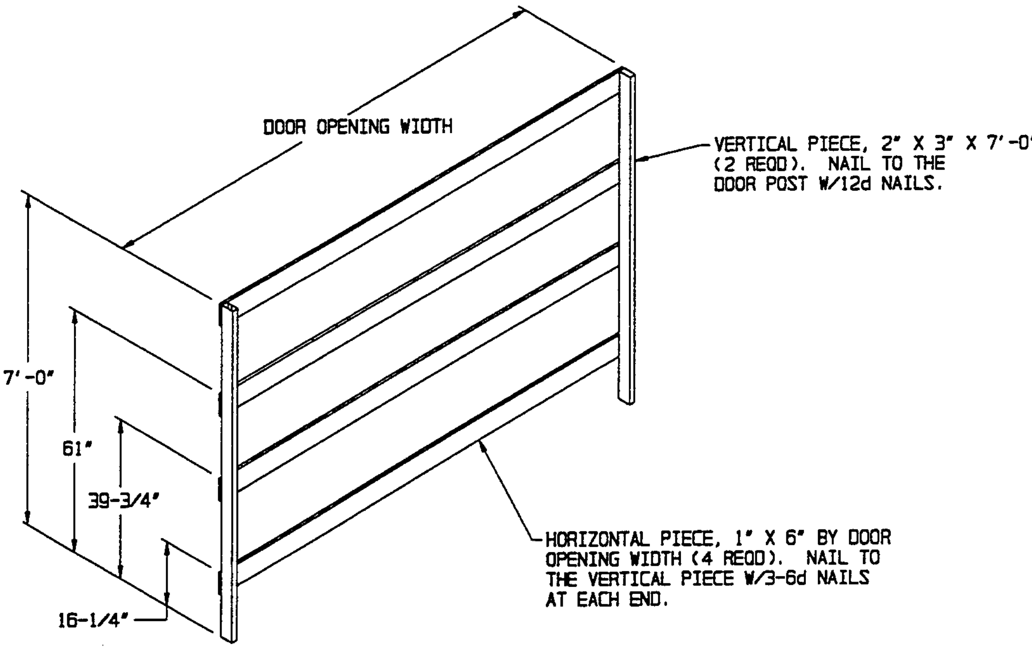
44 pallets of 155 mm
2 pallets of WAM



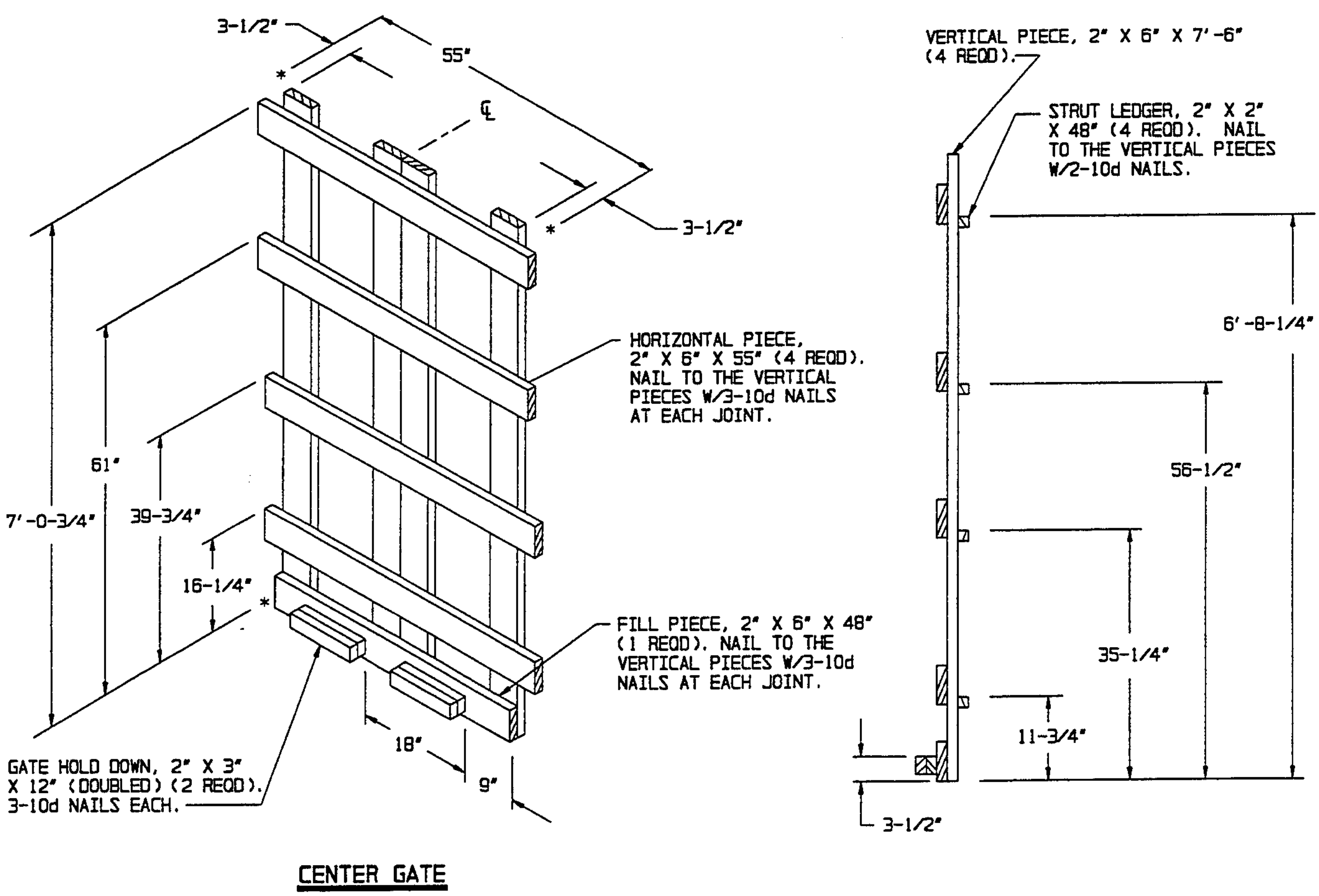
1/3 HEIGHT RISER



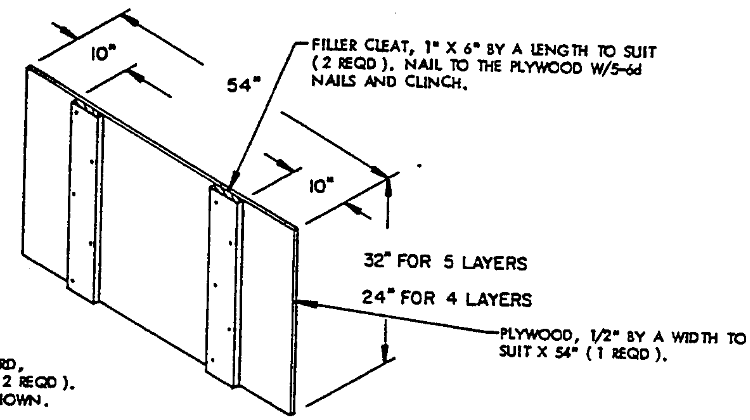
2/3 HEIGHTS RISER



DOORWAY PROTECTION

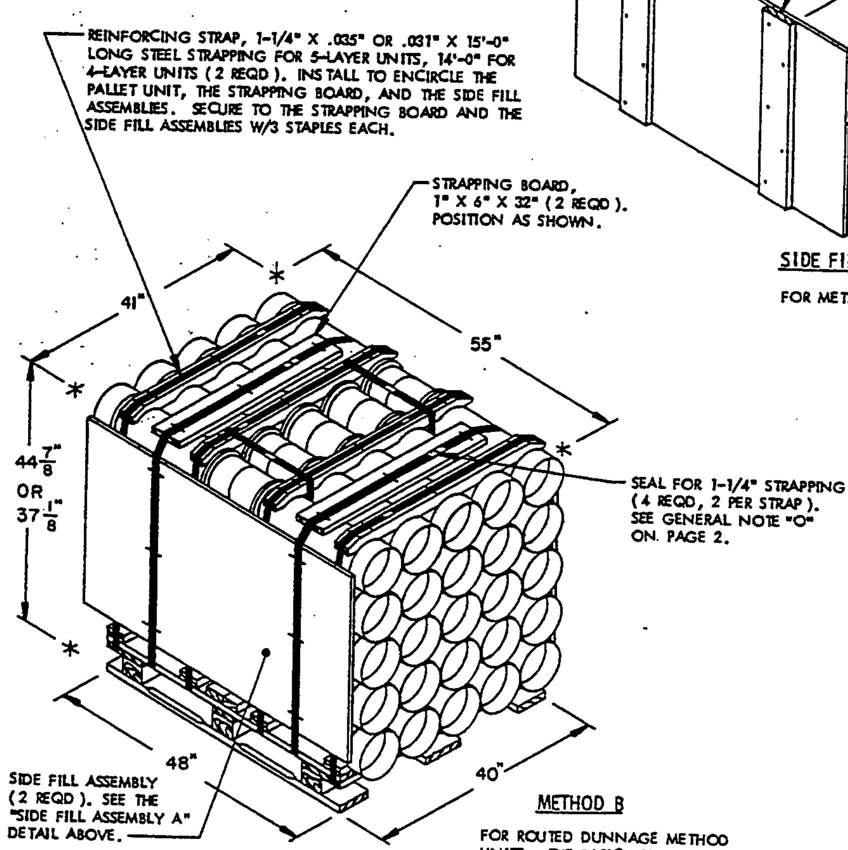


CENTER GATE



SIDE FILL ASSEMBLY A

FOR METHOD "B" BELOW.



METHOD B

FOR ROUTED DUNNAGE METHOD UNITS. THE BASIC HEIGHT UNIT IS SHOWN.

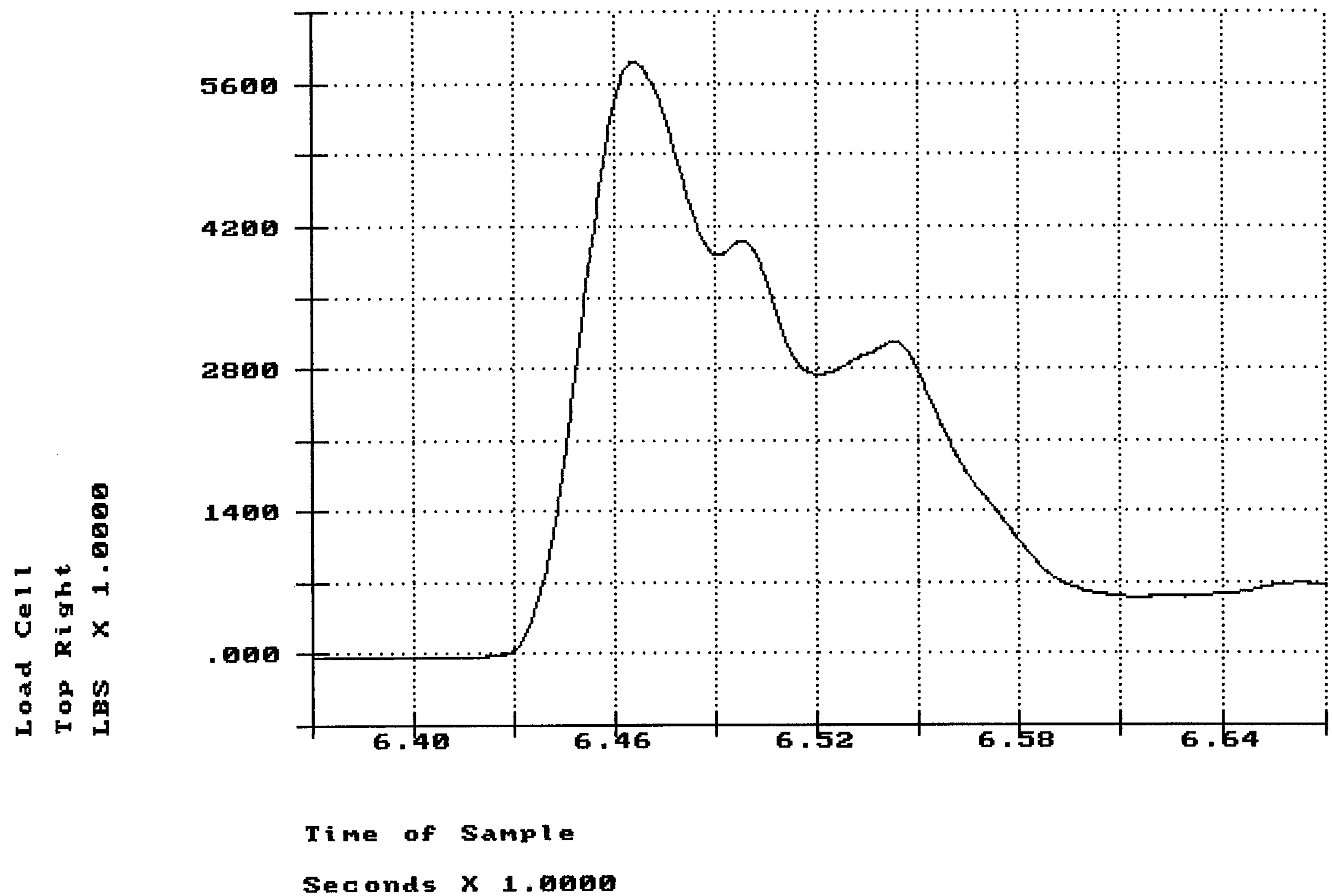
NOTE:

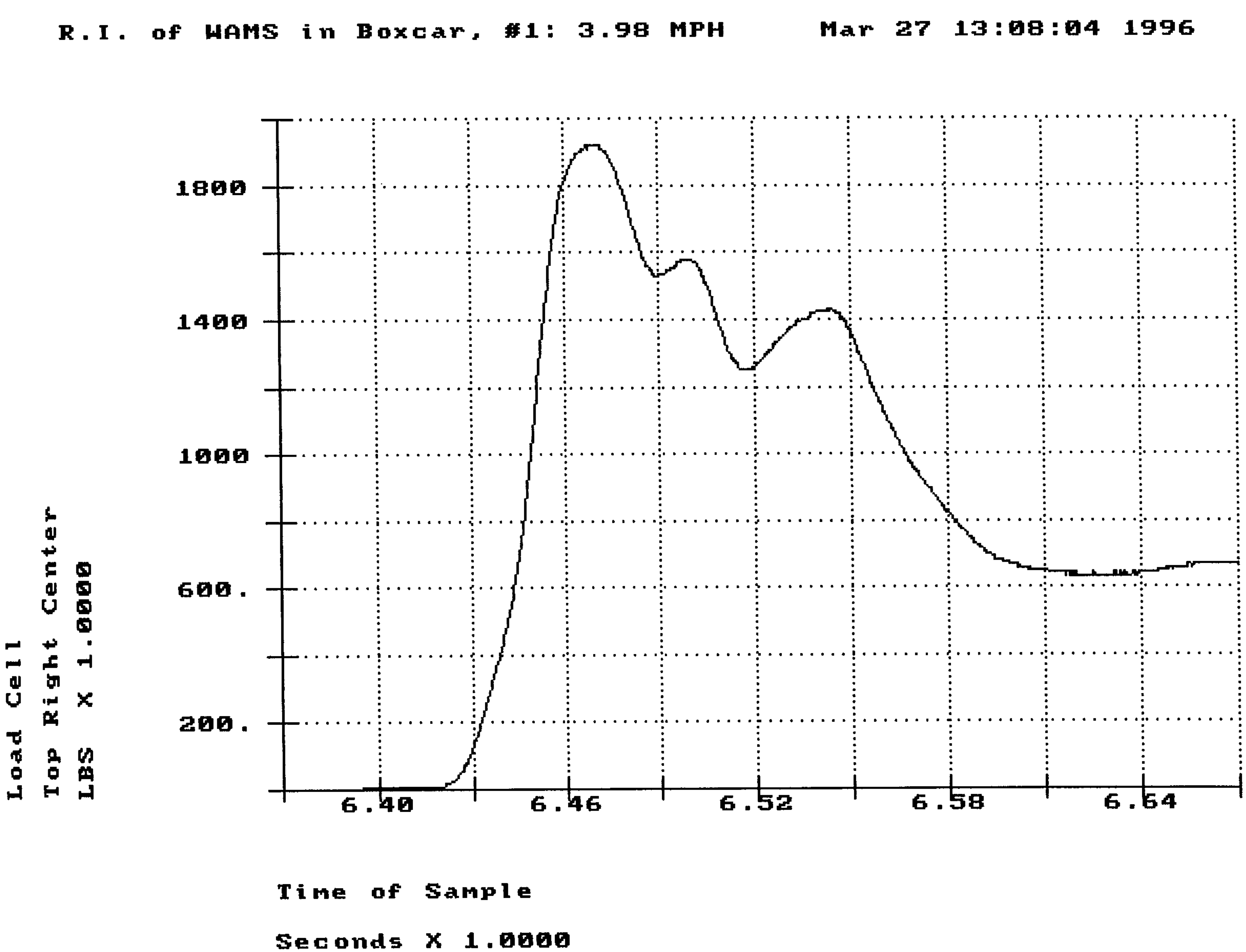
THE "METHOD B" DETAIL AT LEFT SHOWS THE MODIFICATION REQUIRED FOR THE ROUTED DUNNAGE METHOD UNITS WHICH ARE TO BE POSITIONED CROSSWISE IN A CAR WHEN USING THE RISER METHOD OF PARTIAL-LAYER BRACING SHOWN ON PAGE 74. THE BASIC HEIGHT UNIT IS SHOWN, HOWEVER, THE PROCEDURE IS ALSO APPLICABLE FOR THE DECREASED HEIGHT UNIT. FOR MODIFICATION OF ROUTED DUNNAGE METHOD UNITS, TO BE POSITIONED LENGTHWISE IN A CAR, REFER TO THE "METHOD A" DETAIL ABOVE. FOR MODIFICATION OF FLAT DUNNAGE METHOD UNITS TO BE POSITIONED CROSSWISE IN A CAR, REFER TO THE "METHOD C" DETAIL ON PAGE 77.

PART 8

GRAPHS

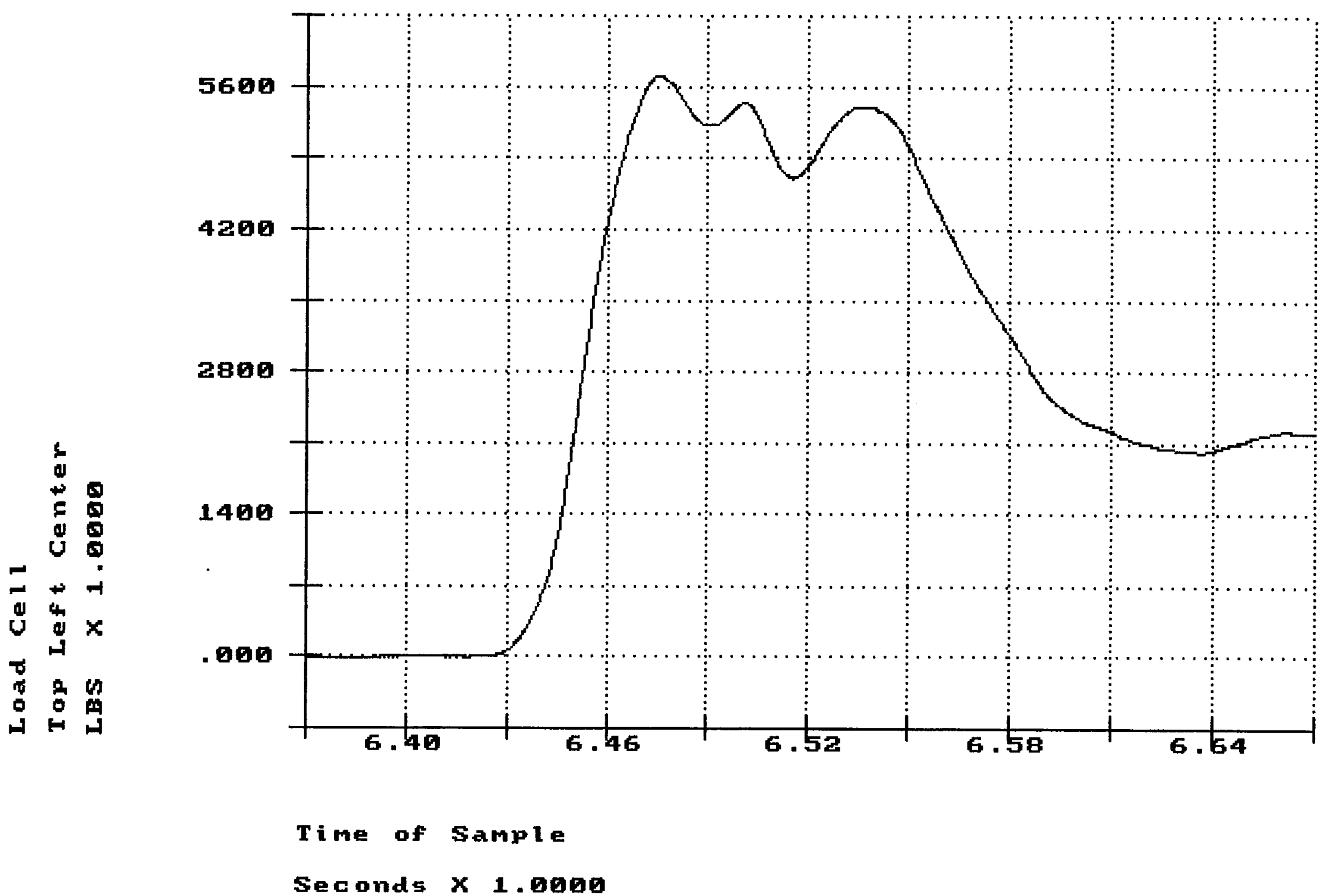
R.I. of WAMS in Boxcar, #1: 3.98 MPH   Mar 27 13:08:04 1996

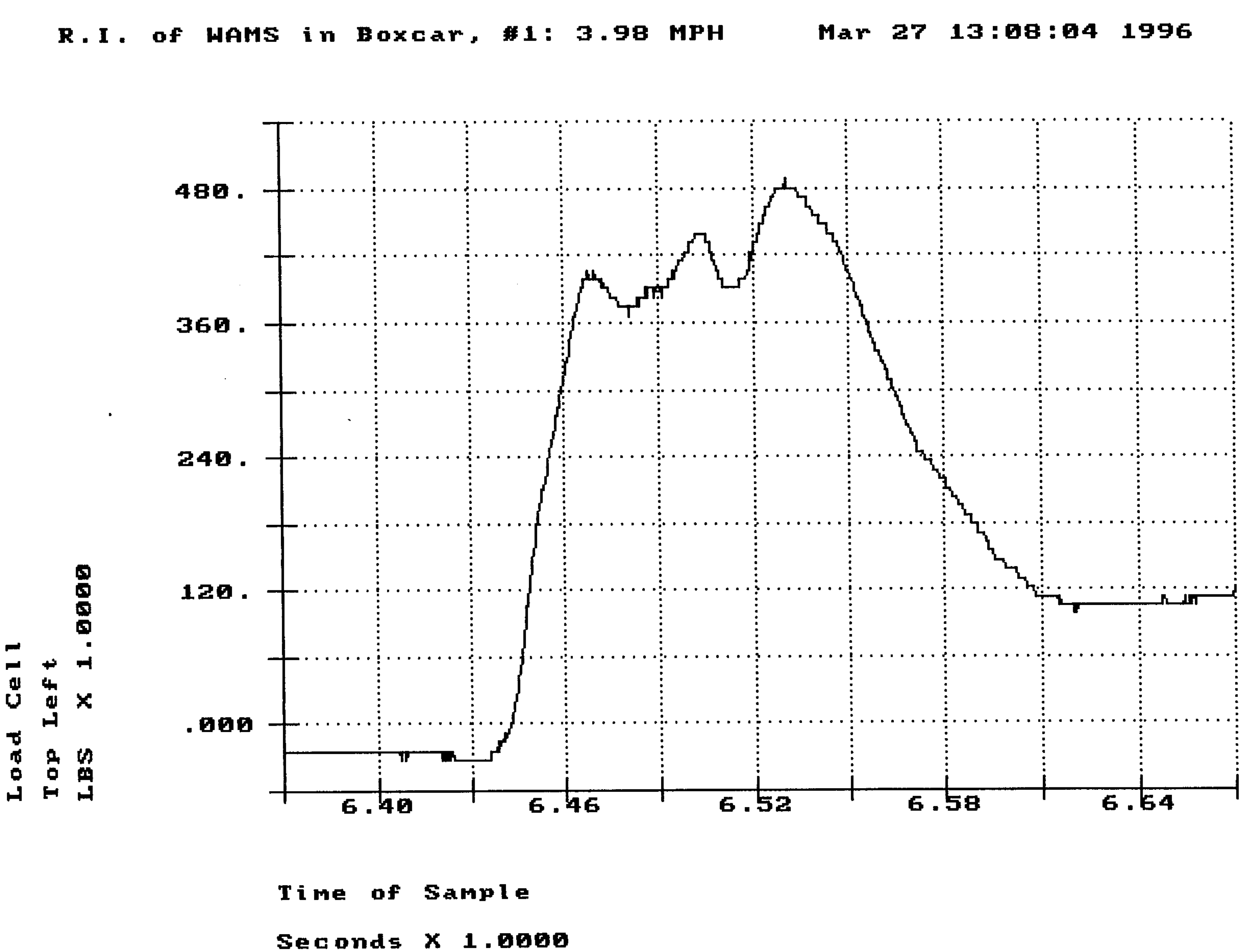




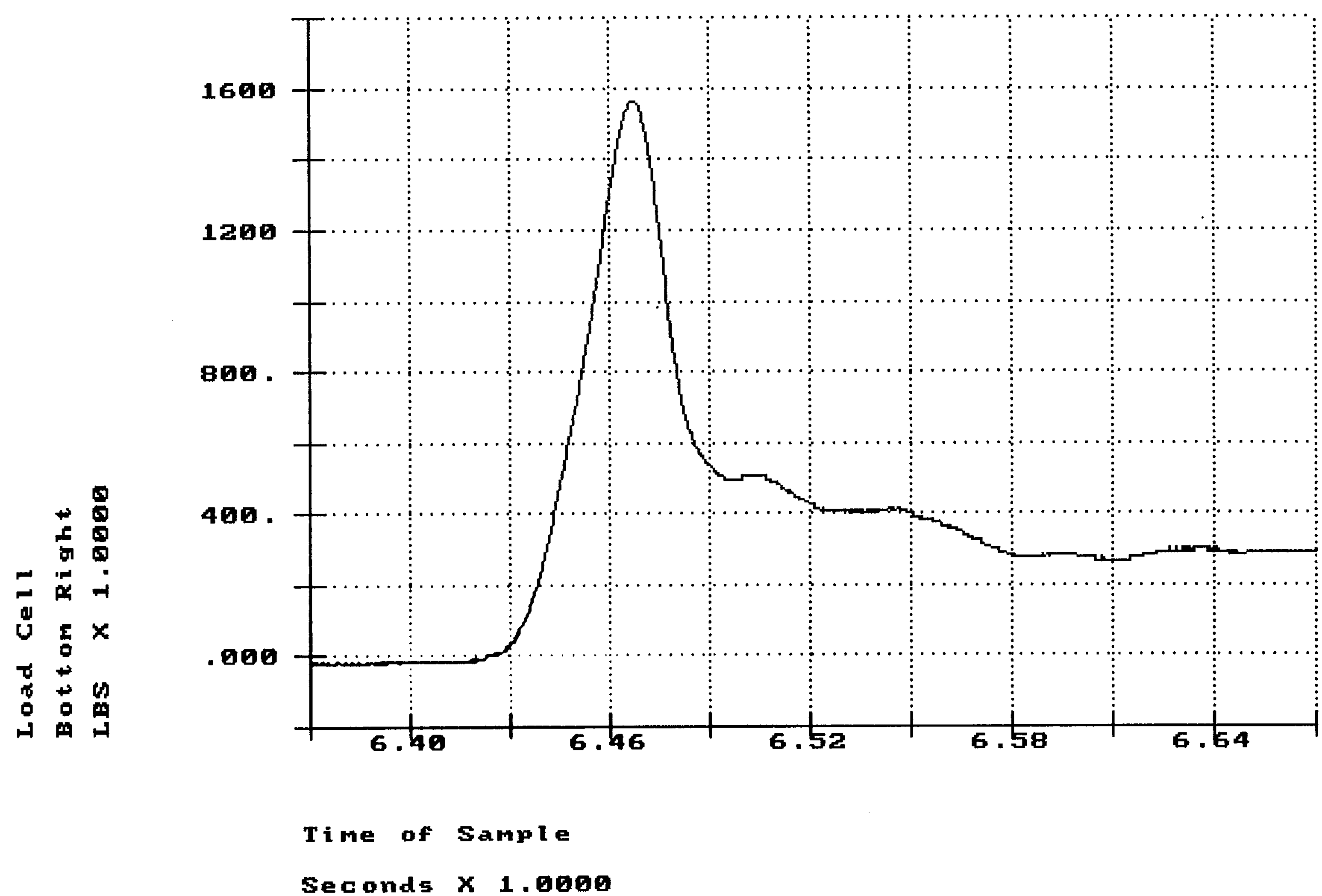
R.I. of WAMS in Boxcar, #1: 3.98 MPH
Mar 27 13:08:04 1996
1800
1400
1000
600.
200.
6.40
6.46
6.52
6.58
6.64
Load Cell
Top Right Center
LBS X 1.0000
Time of Sample
Seconds X 1.0000

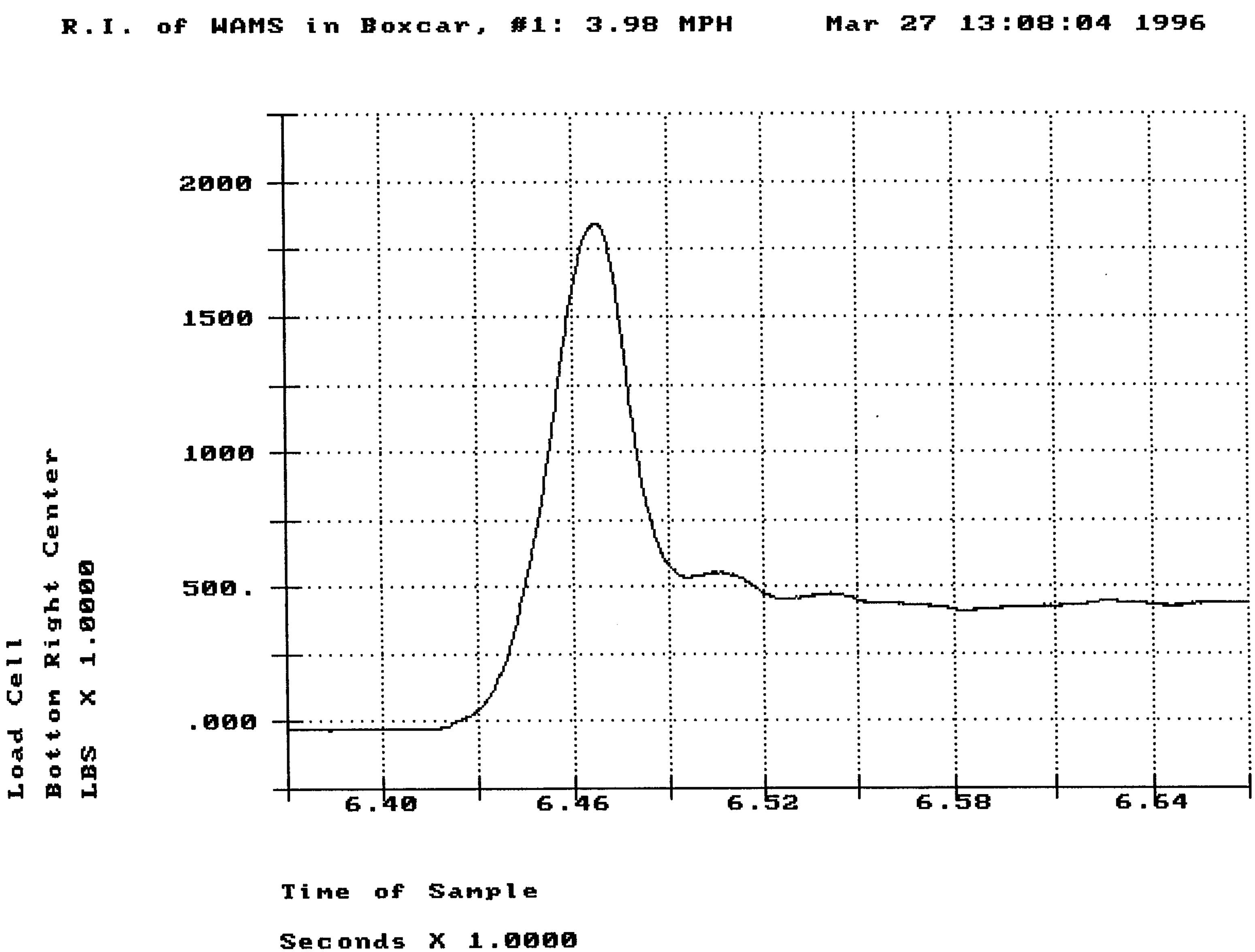
R.I. of WAMS in Boxcar, #1: 3.98 MPH   Mar 27 13:08:04 1996



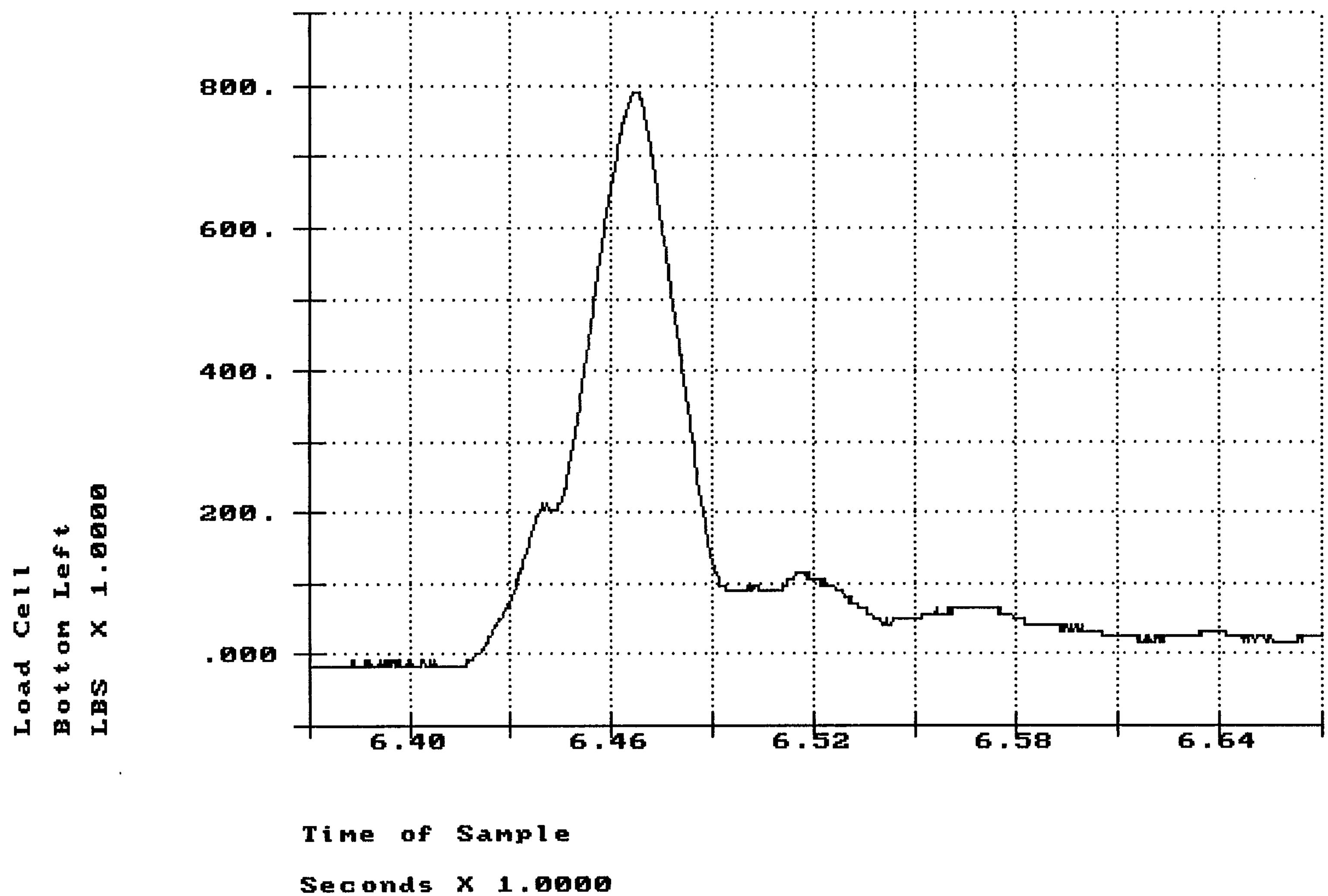

R.I. of WAMS in Boxcar, #1: 3.98 MPH
Mar 27 13:08:04 1996
480.
360.
240.
120.
.000
Load Cell
Top Left
LBS X 1.0000
6.40
6.46
6.52
6.58
6.64
Time of Sample
Seconds X 1.0000

R.I. of WAMS in Boxcar, #1: 3.98 MPH Mar 27 13:08:04 1996

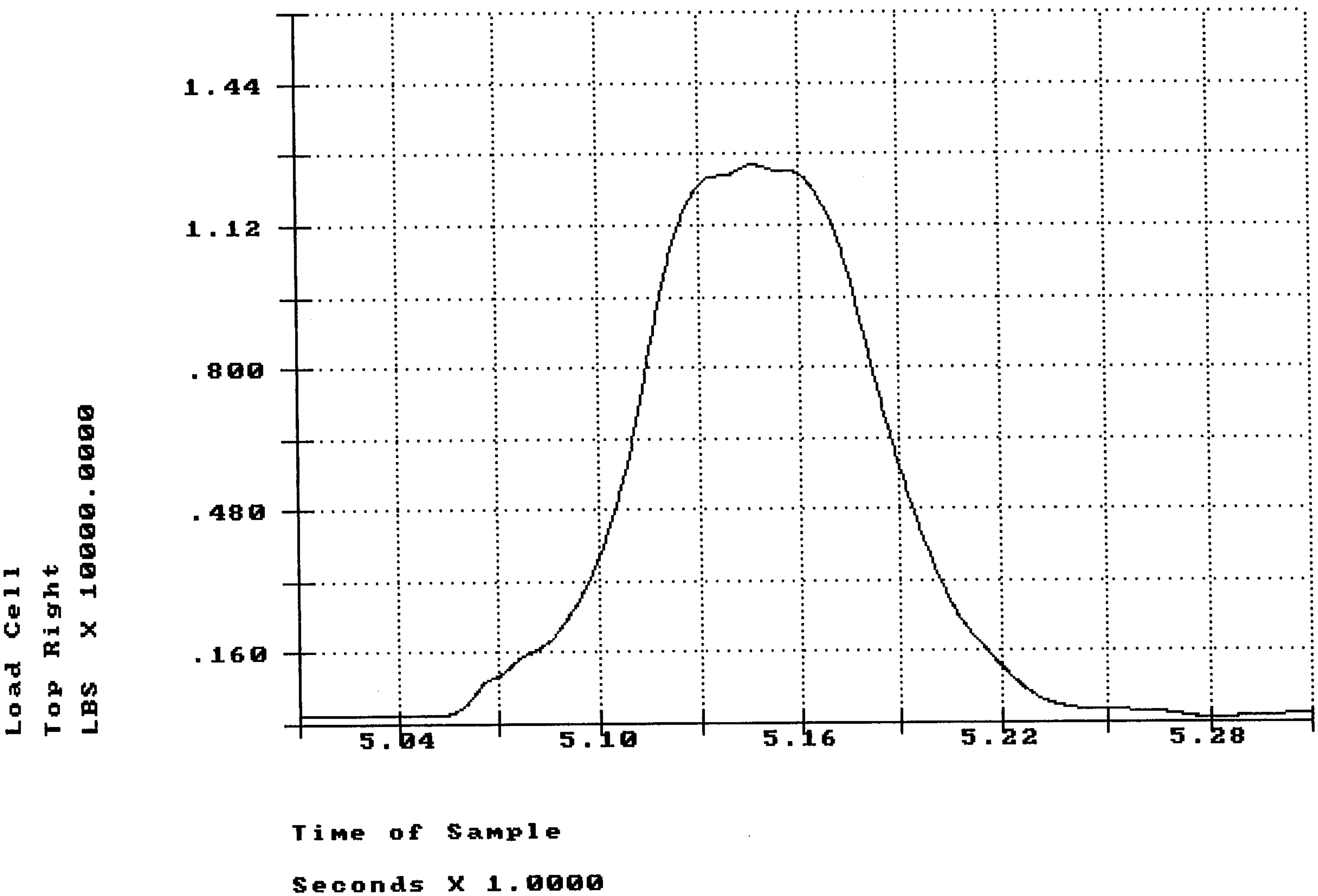



R.I. of WAMS in Boxcar, #1: 3.98 MPH
Mar 27 13:08:04 1996
2000
1500
1000
500.
.000
6.40
6.46
6.52
6.58
6.64
Load Cell
Bottom Right Center
LBS X 1.0000
Time of Sample
Seconds X 1.0000

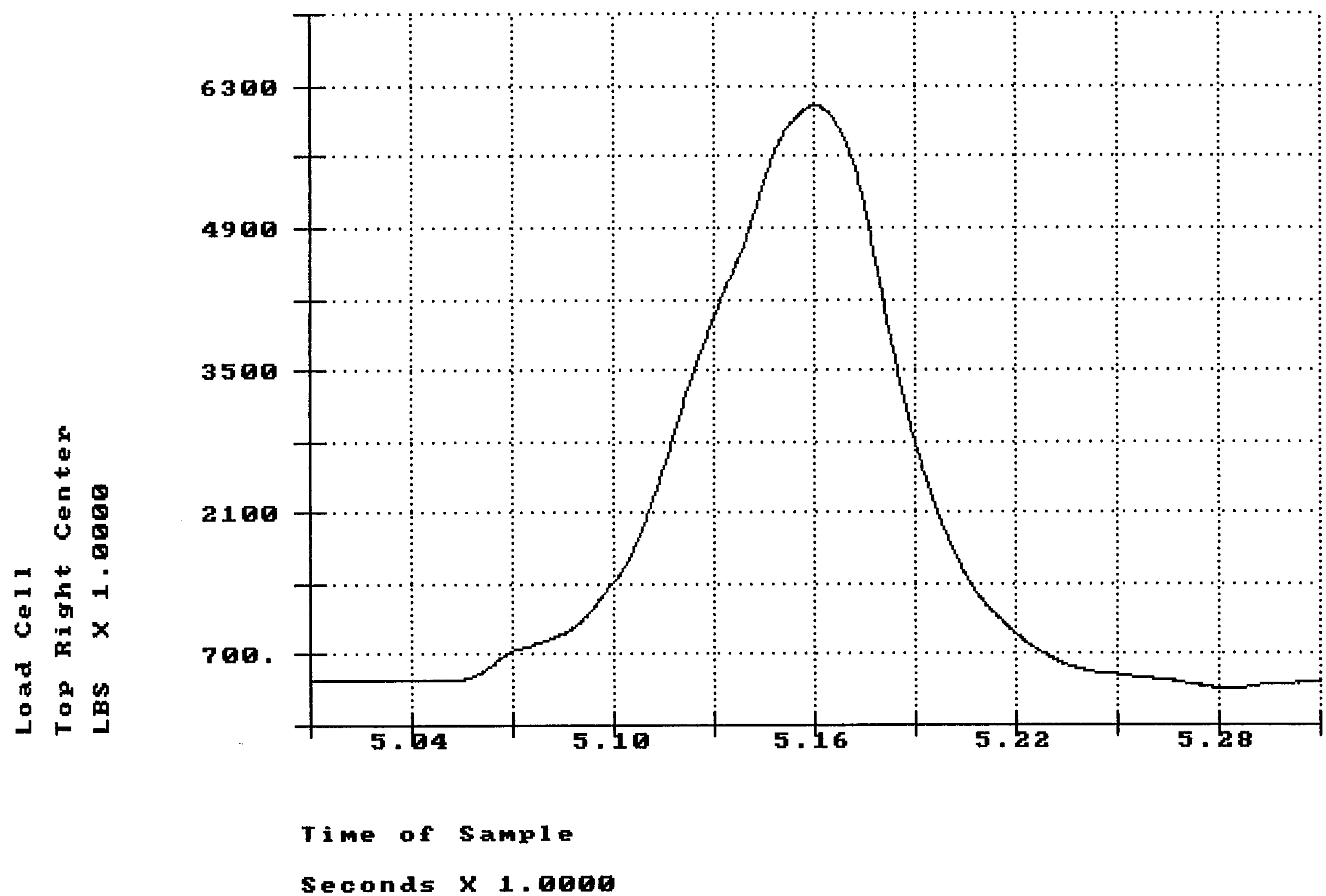
R.I. of WAMS in Boxcar, #1: 3.98 MPH Mar 27 13:08:04 1996



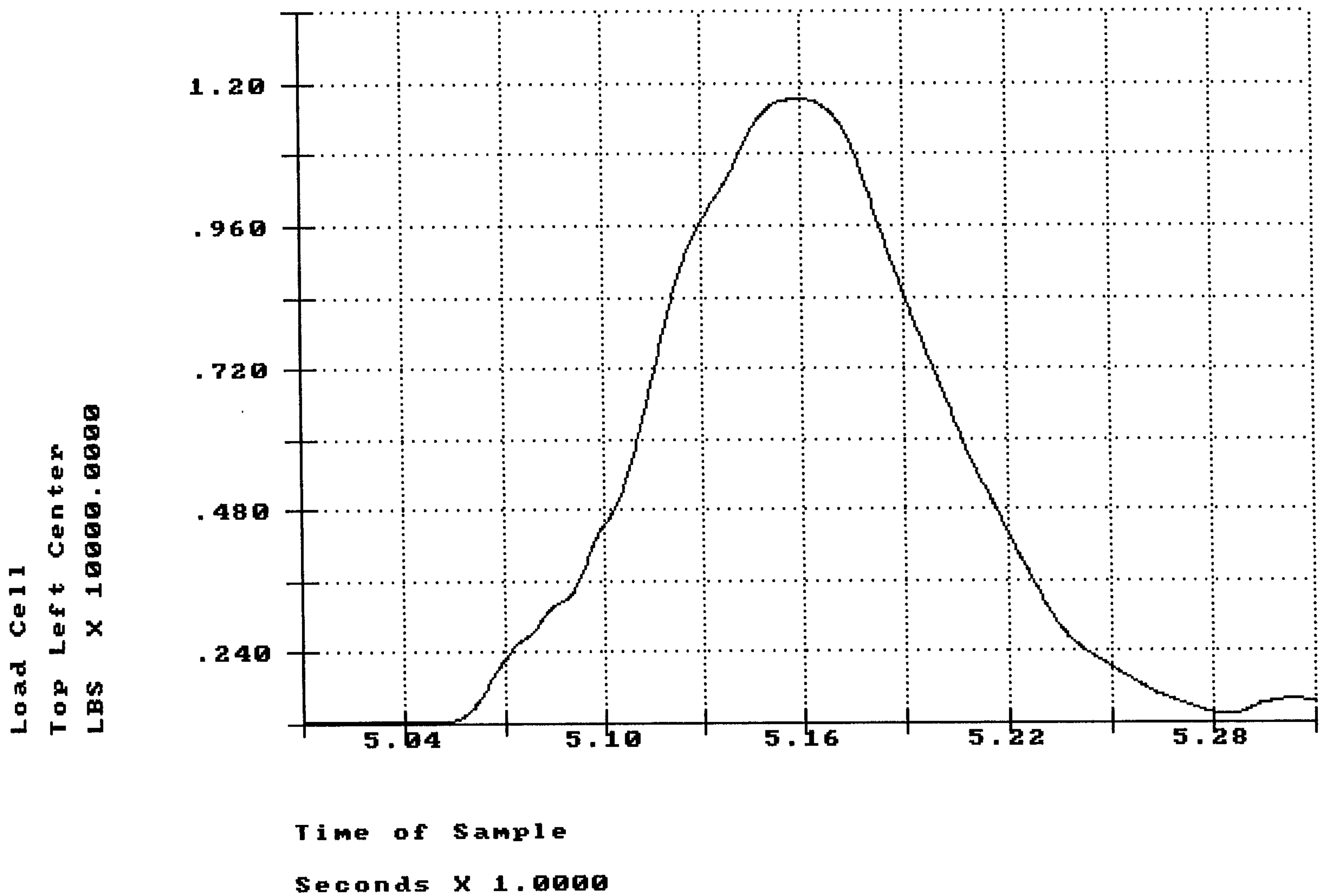
R.I. of WAMS in Boxcar, #2: 5.86 MPH   Mar 27 13:16:06 1996



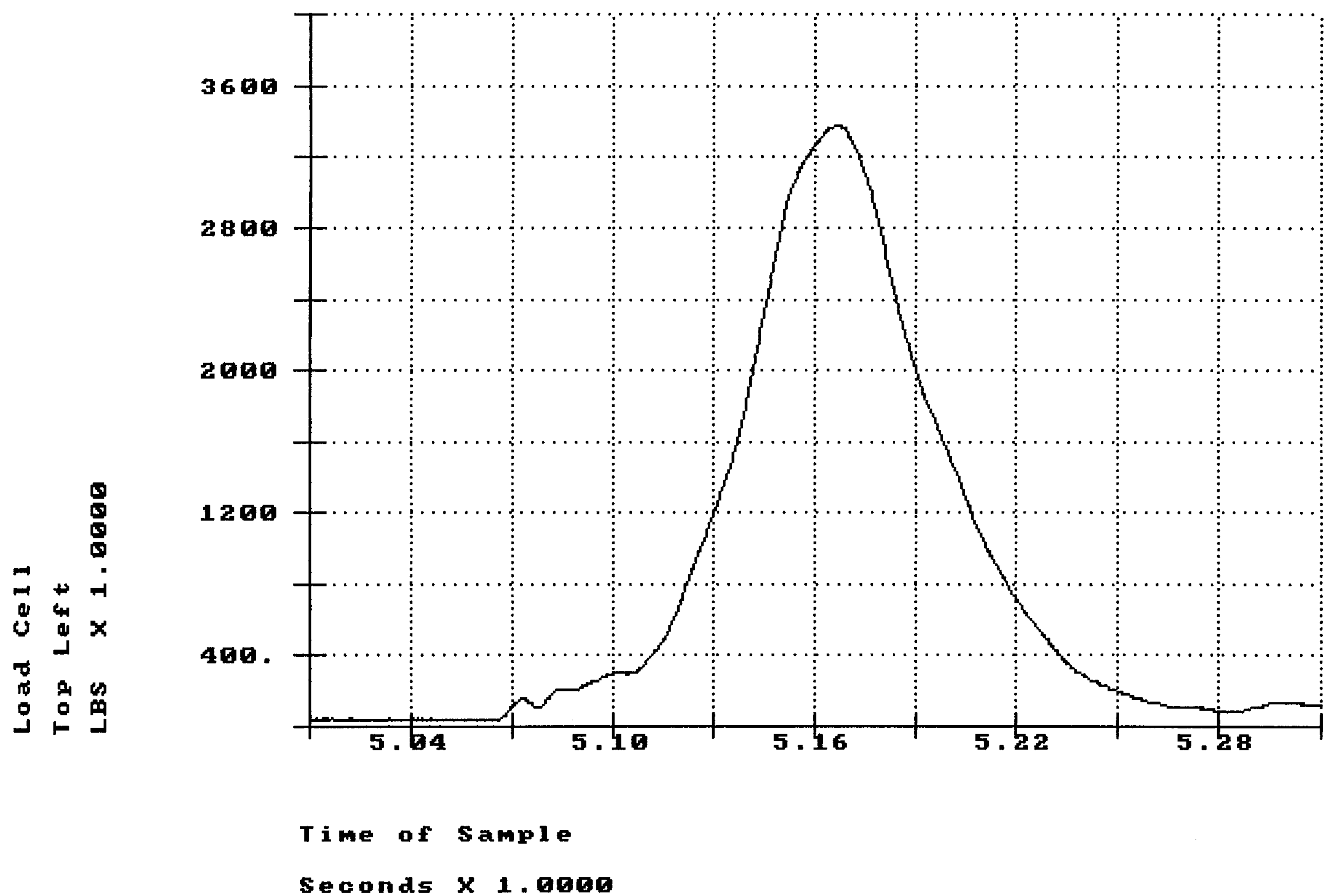
R.I. of WAMS in Boxcar, #2: 5.86 MPH Mar 27 13:16:06 1996



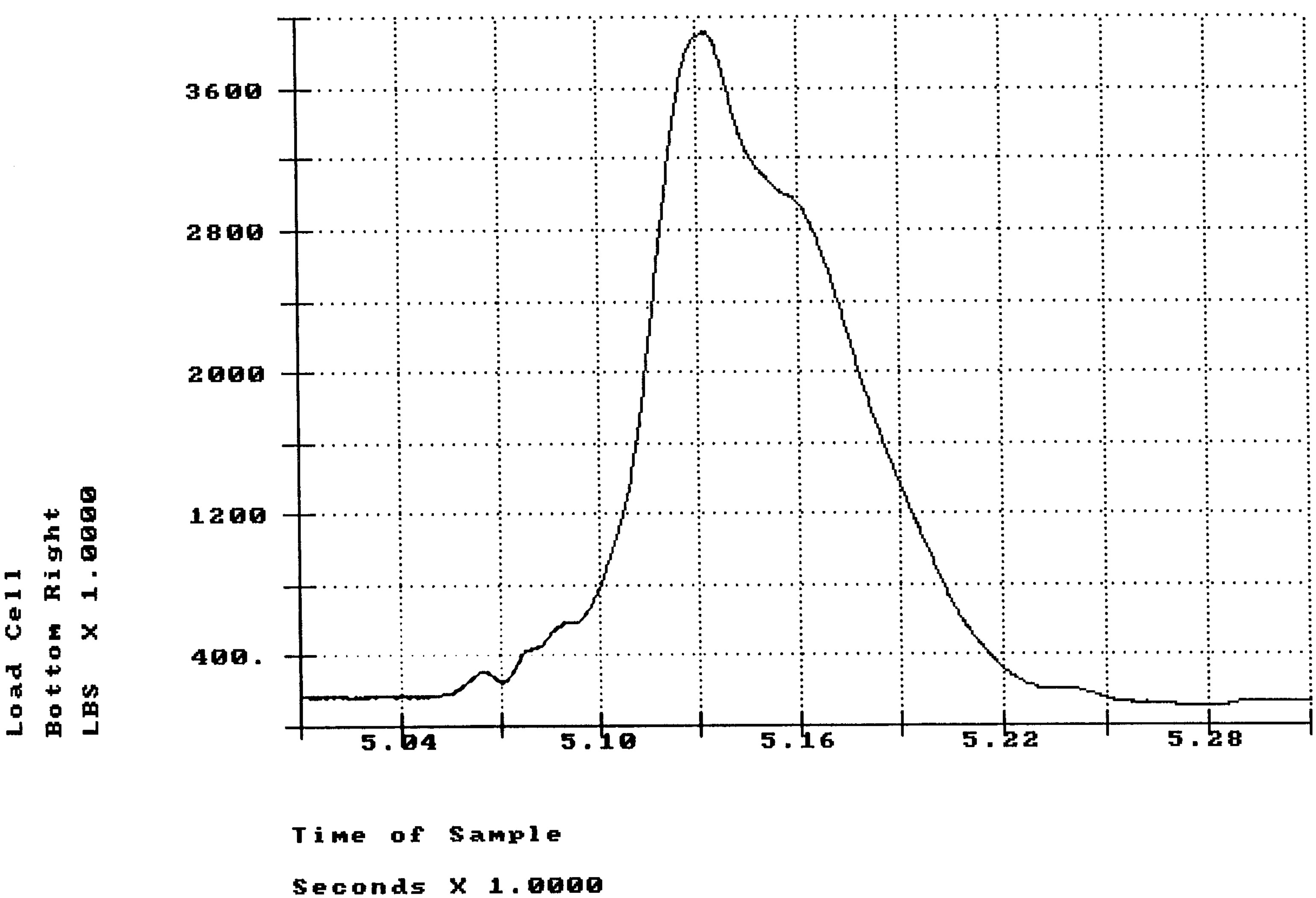
R.I. of WAMS in Boxcar, #2: 5.86 MPH   Mar 27 13:16:06 1996



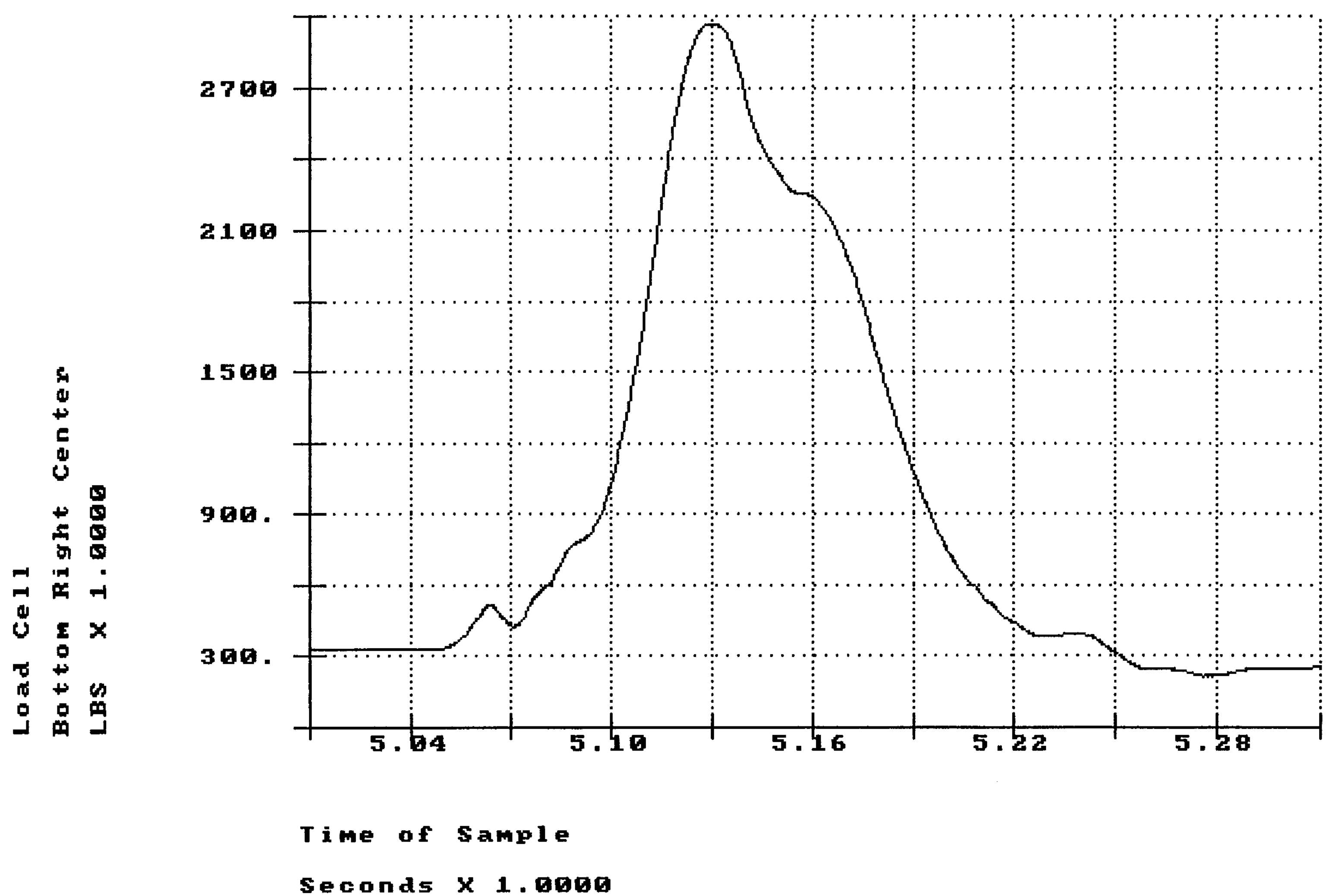
R.I. of WAMS in Boxcar, #2: 5.86 MPH   Mar 27 13:16:06 1996



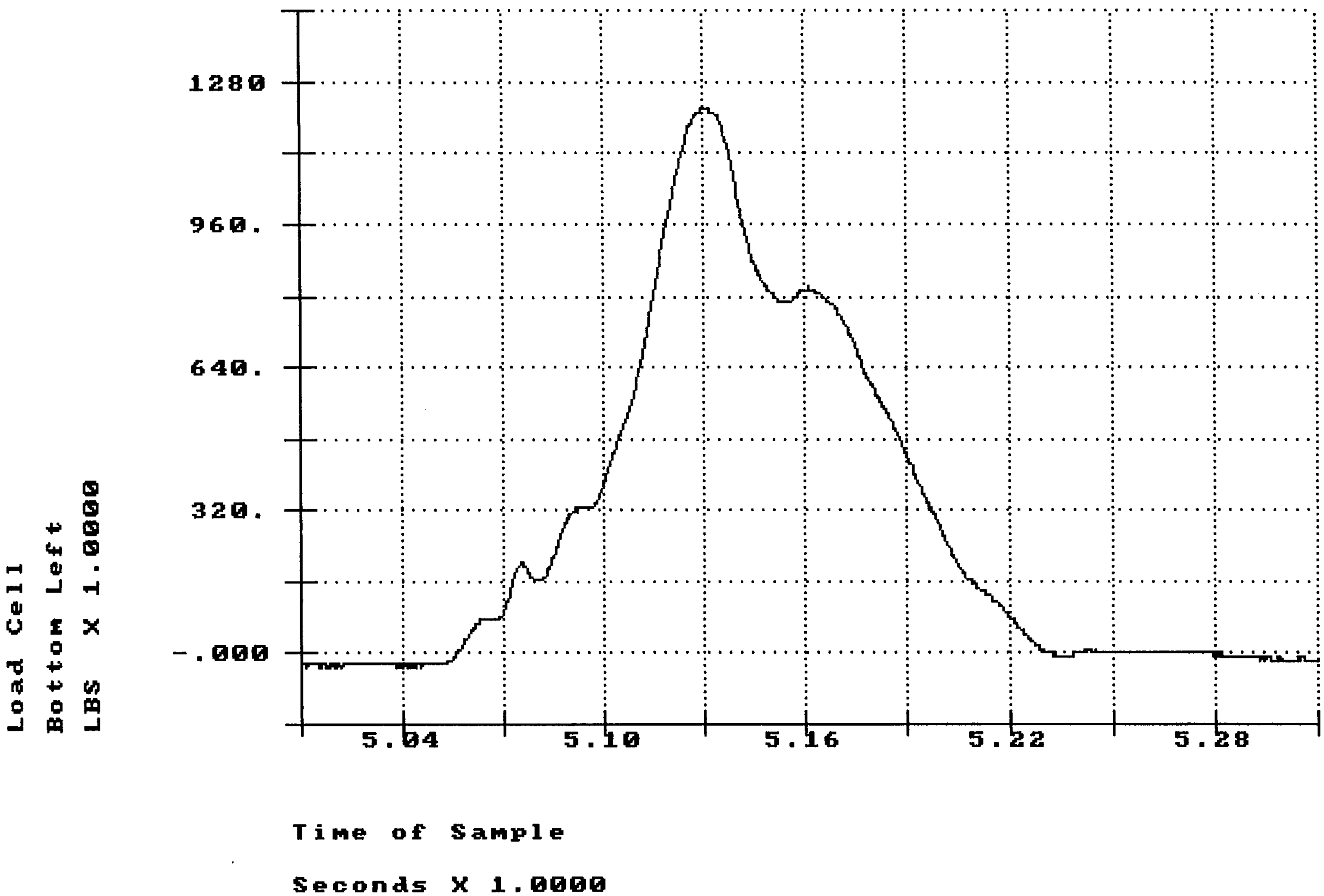
R.I. of WAMS in Boxcar, #2: 5.86 MPH Mar 27 13:16:06 1996



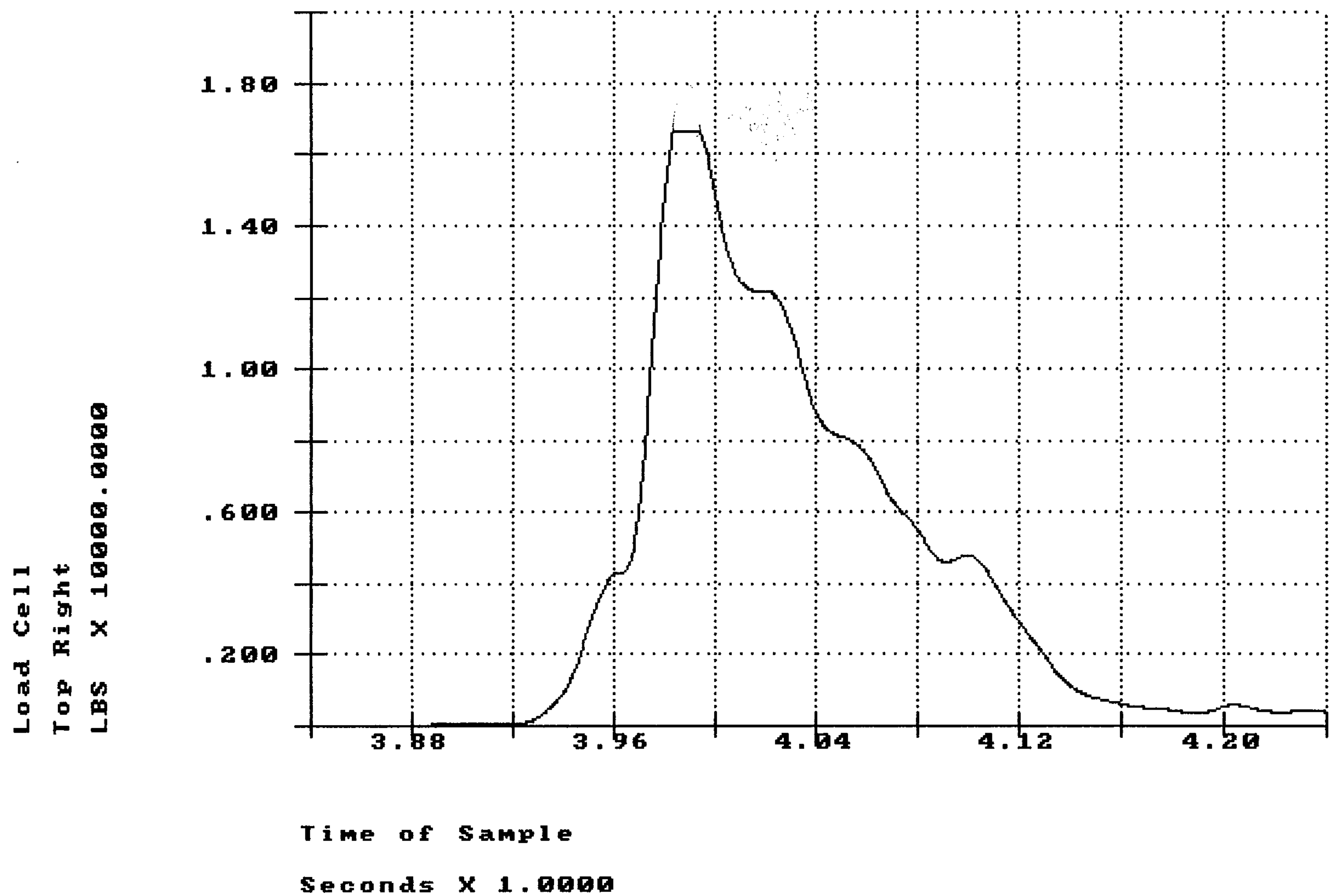
R.I. of WAMS in Boxcar, #2: 5.86 MPH Mar 27 13:16:06 1996



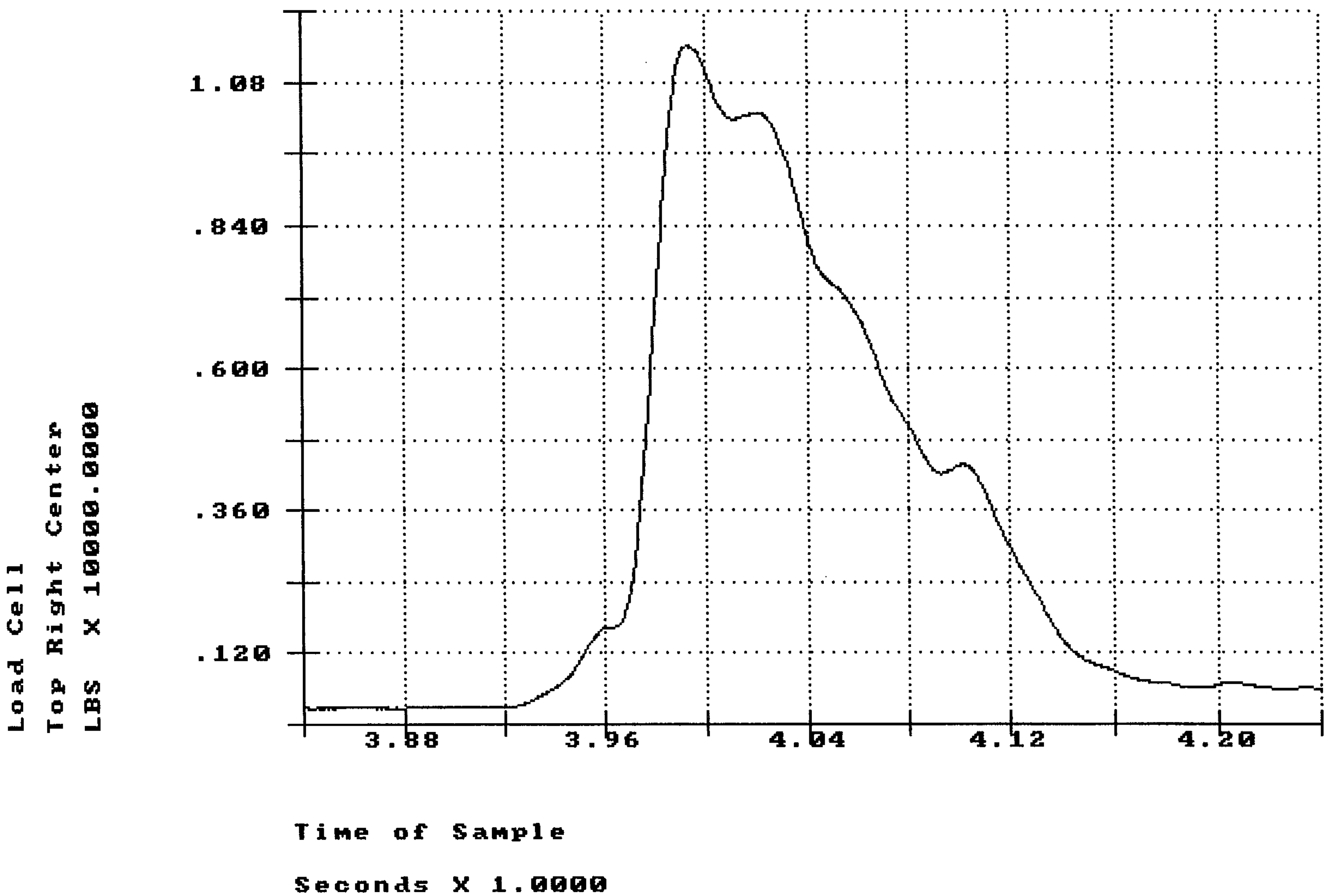
R.I. of WAMS in Boxcar, #2: 5.86 MPH Mar 27 13:16:06 1996



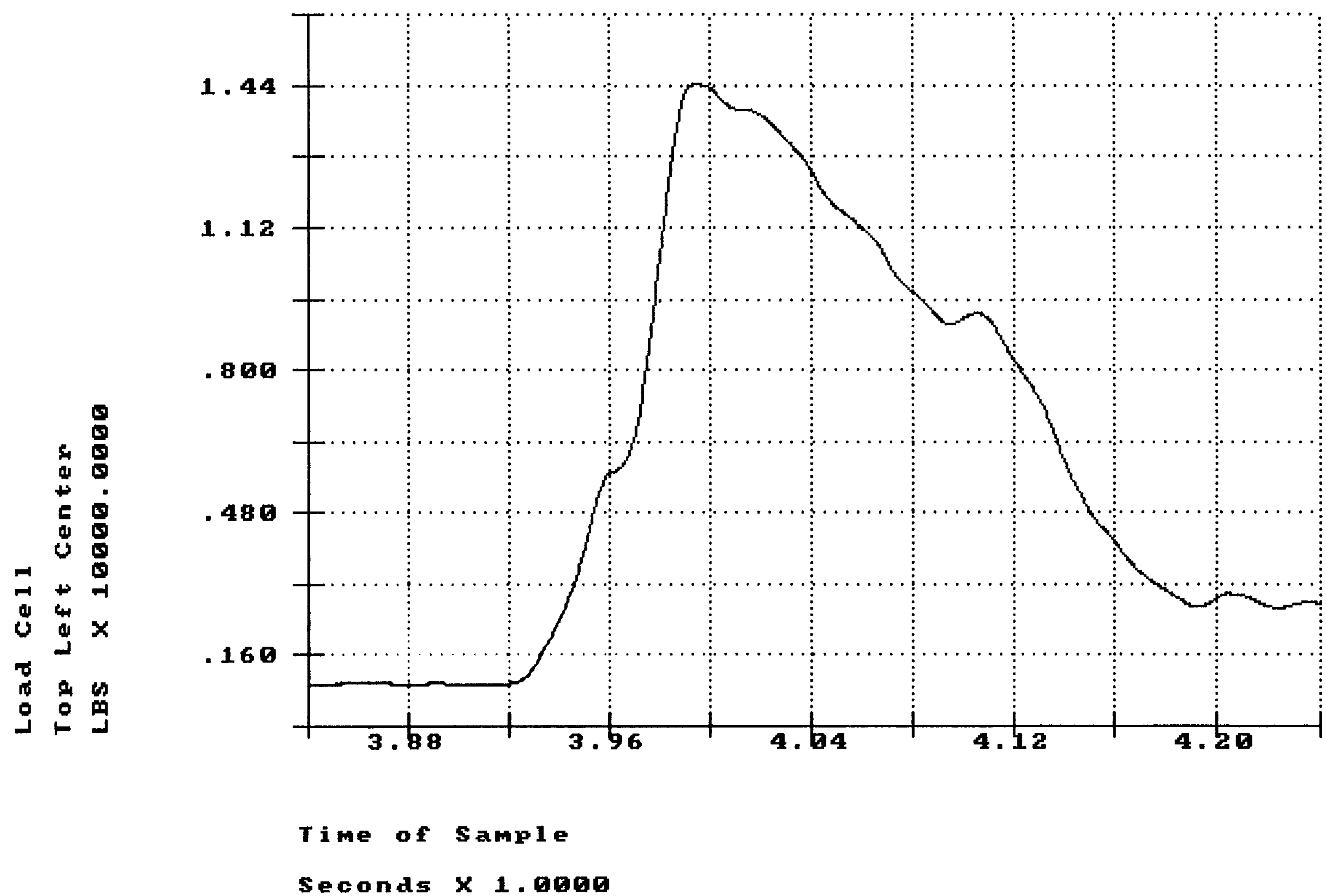
R.I. of WAMS in Boxcar, #3: 9.49 MPH   Mar 27 13:26:46 1996



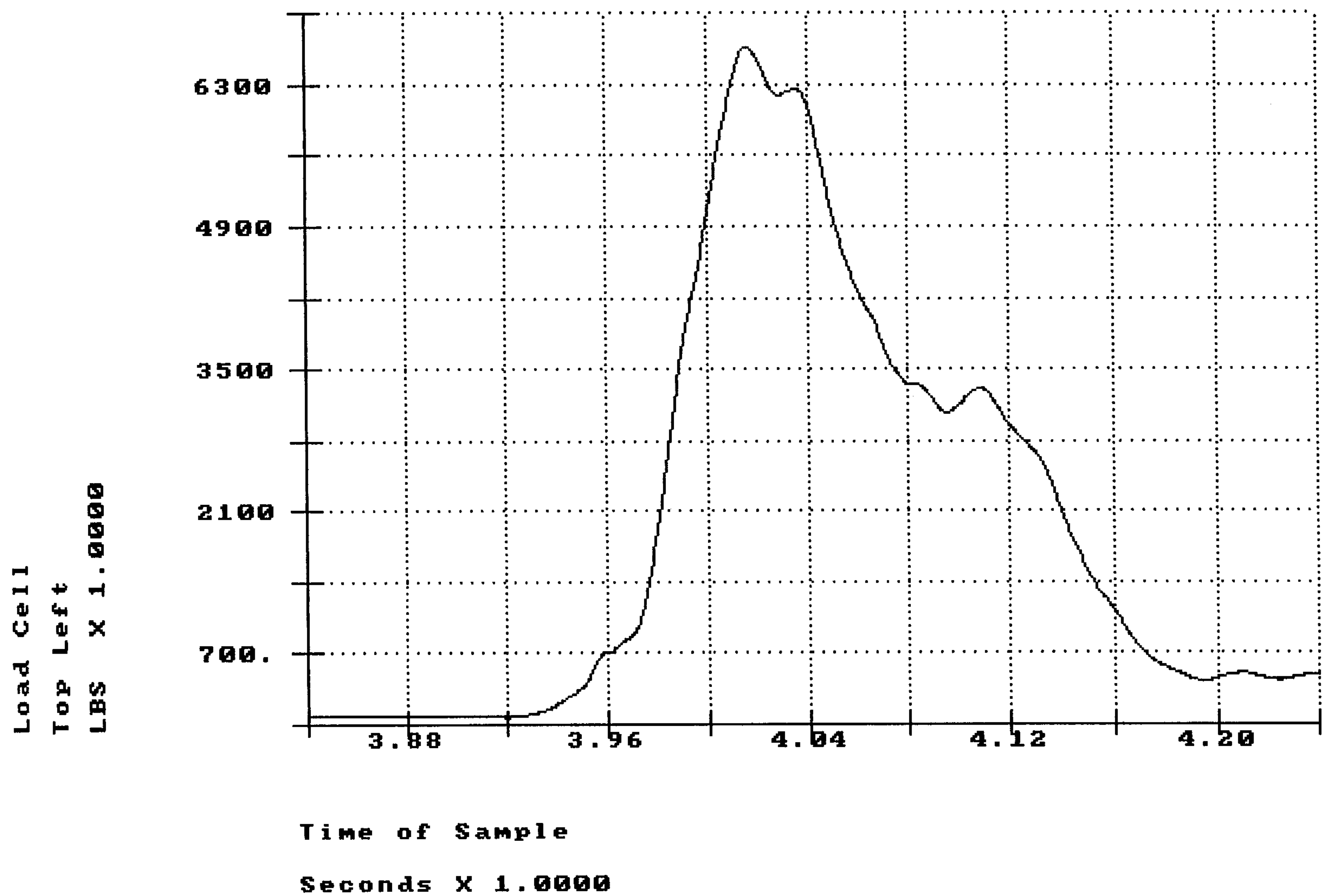
R.I. of WAMS in Boxcar, #3: 9.49 MPH Mar 27 13:26:46 1996



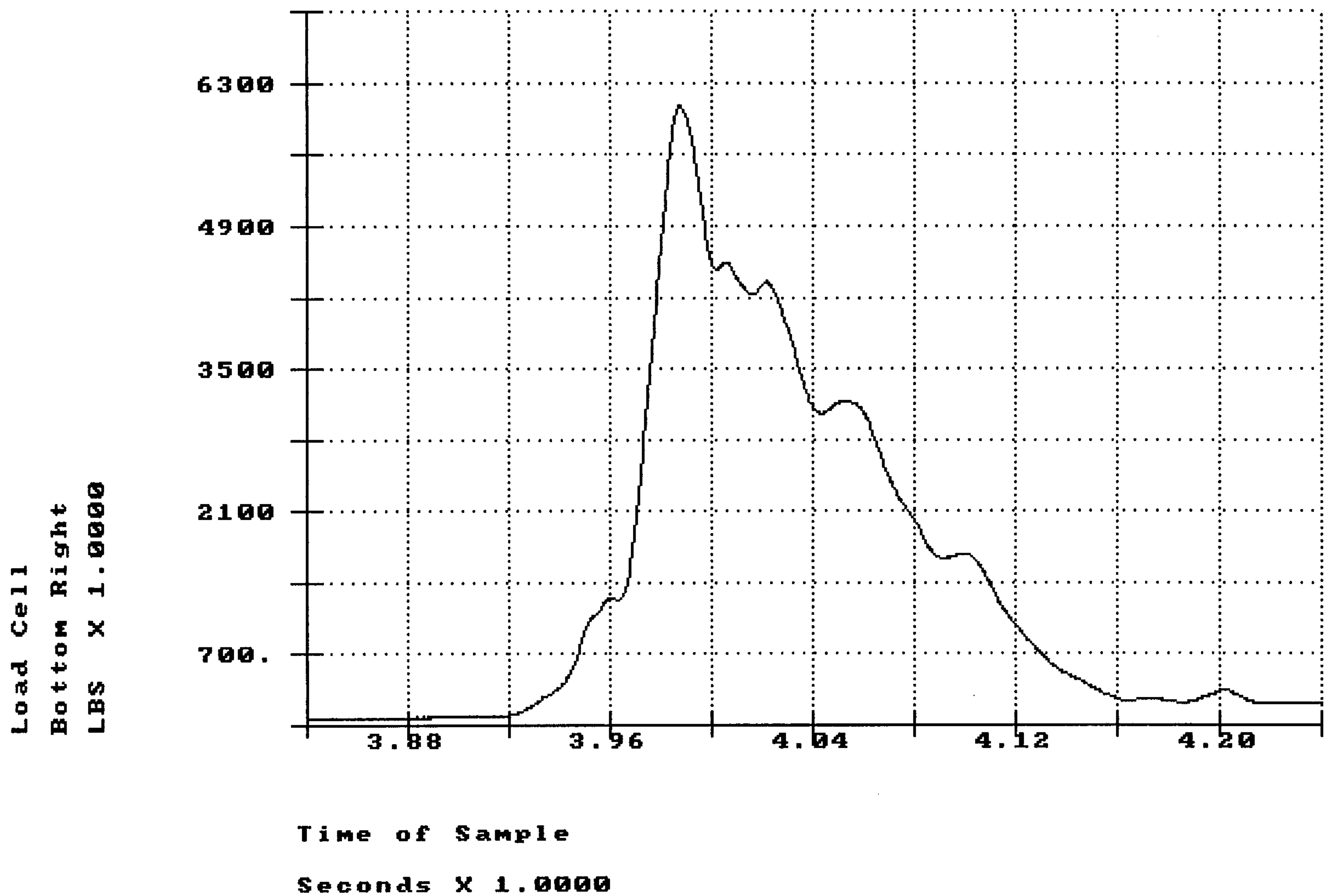
R.I. of WAMS in Boxcar, #3: 9.49 MPH   Mar 27 13:26:46 1996



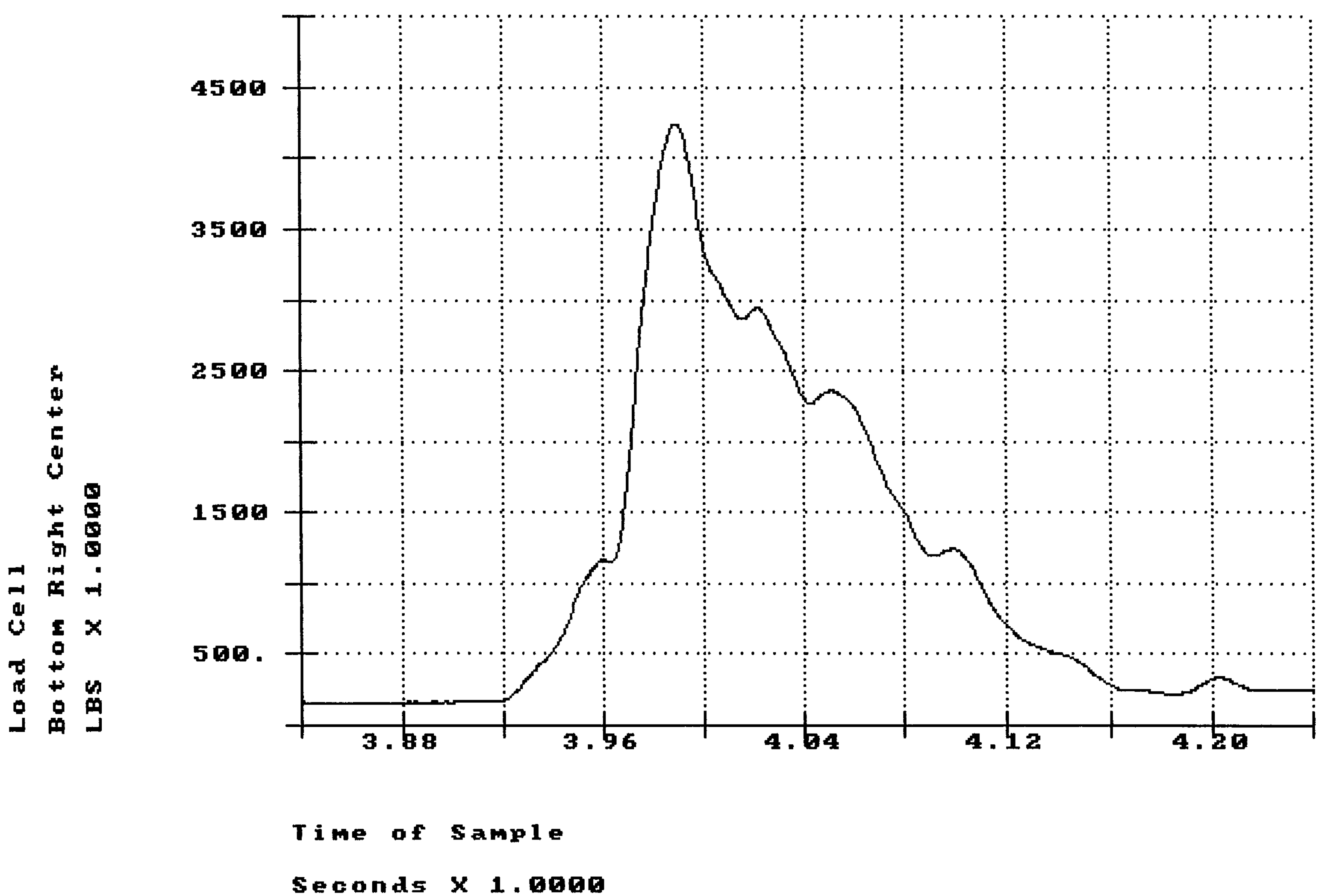
R.I. of WAMS in Boxcar, #3: 9.49 MPH   Mar 27 13:26:46 1996



R.I. of WAMS in Boxcar, #3: 9.49 MPH   Mar 27 13:26:46 1996



R.I. of WAMS in Boxcar, #3: 9.49 MPH   Mar 27 13:26:46 1996



R.I. of WAMS in Boxcar, #3: 9.49 MPH   Mar 27 13:26:46 1996